ENERGY CONSERVATION IN MULTI-UNIT RESIDENTIAL BUILDINGS

Property Managers' Manual

Ontario
Ministry of Municipal Affairs and Housing
Hon. Claude F. Bennett
Minister

Energy Ontario

IHM Institute of Housing Management

ENERGY CONSERVATION IN MULTI-UNIT RESIDENTIAL BUILDINGS

Property Manager's Manual

This Manual has been prepared on behalf of the Ministry of Municipal Affairs and Housing and the Institute of Housing Management by:

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Ministry of Municipal Affairs and Housing,
Queen's Park, Ontario.

May, 1983.

CONTENTS

The Property Manager's Manual describes energy conservation methods and measures for multi-unit residential buildings. It is a reference manual for property managers, building superintendents, maintenance personnel and building owners.

The Manual outlines energy conservation measures for all types of multi-unit housing, including townhouses, walk-up apartment buildings and high-rise developments. The measures address all major building systems, including heating, cooling, mechanical ventilation and exhaust, water supply, lighting, appliances and the building envelope. Emphasized throughout are practical, proven measures that can produce energy conservation results cost-effectively.

ENERGY CONSERVATION IN MULTI-UNIT RESIDENTIAL BUILDINGS

Energy, purchased as electricity, natural gas, oil, propane and other fuels, is becoming increasingly expensive. Energy represents a large and growing proportion of total building operating costs. Figure I-1 shows a breakdown of annual operating costs for a typical multi-unit building. Utility expenses, most of which are energy costs, represent 23% of the total.

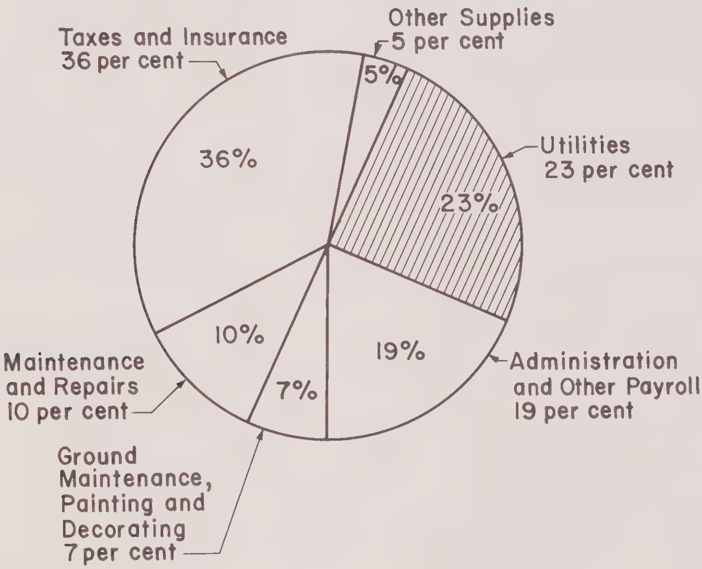

Fig. I-I
ANNUAL OPERATING COSTS FOR A TYPICAL MULTI-UNIT BUILDING
Source: CMHC

INTRODUCTION 1.2

Energy is a major expense and a very important factor in the overall management of multi-unit buildings. Energy conservation, therefore, can be vital to successful property management.

There are numerous opportunities in multi-unit residential buildings for major reductions in energy expenditures. In many cases, reductions can be achieved through simple, practical measures that can be applied quickly and easily with little or no capital investment. In fact, energy costs can be reduced more quickly and effectively than other operating expenses including administration costs, maintenance, decorating, taxes, insurance, etc.

Energy conservation can lead to several other benefits in addition to cost savings. For example, well-tuned and efficiently operated mechanical systems last longer. Air-sealed and insulated apartments are more comfortable. Many energy conservation measures also add to the value of the building.

ENERGY CONSERVATION IN ONTARIO

Energy conservation in multi-unit residential buildings is not only important to building owners and property managers; it is essential to the success of Ontario's overall energy conservation effort. Multi-unit residential buildings currently consume about 35% of the total energy used in Ontario's residential sector.[1] The residential sector, in turn, consumes 21% of the total energy used in Ontario.[2] Conservation in multi-unit residential buildings will make an important and necessary contribution to achieving the Province's long term goal of energy security.

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1. Ministry of Municipal Affairs and Housing
2. Ministry of Energy, Ontario Energy Review, March 1981

The Property Manager's Manual is designed as a practical reference tool. It is intended to be improved over time as new conservation technologies are developed, and to be adapted by each user to suit specific buildings and particular energy conservation requirements. The Manual's loose leaf format permits periodic updating and expansion. Subscribers will receive new material as it is produced. In addition, each user can insert relevent material from other sources.

Sections 3 through 8 are organized as follows:

SECTION 3: ENERGY USE IN BUILDINGS

A basic understanding of how energy is used, measured and priced will assist in selecting and implementing energy conservation measures.

Section 3 provides an overview of important background information regarding Energy Use in Buildings.

SECTION 4: ENERGY MANAGEMENT

Section 4 outlines approaches, methods and techniques for Energy Management.

This section is designed to assist users of the Manual in selecting appropriate energy conservation measures for a particular building, and in planning long term conservation strategies as part of property management.

SECTION 5: ENERGY CONSERVATION MEASURES

Section 5 catalogues a broad range of energy conservation measures available to property managers. The measures are organized into seven sub-sections, each representing a major building system:

- Heating
- Cooling
- Mechanical Ventilation/Exhaust
- Water Supply
- Building Envelope
- Lighting
- Appliances

Each sub-section begins with a brief description of the system. This is followed by a series of **summary sheets** for energy conservation measures.

Summary sheets are designed for quick and easy reference. Each sheet describes a specific energy conservation measure in a standard format, including:

- identification of the building **system**
- identification of the **measure**
- **application** to various building types and system types
- **discussion** of the measure
- estimated **savings**
- estimated **costs**
- **cautions** to be observed
- notes to assist in **implementation**

Summary sheet format is illustrated in Figure G-1.

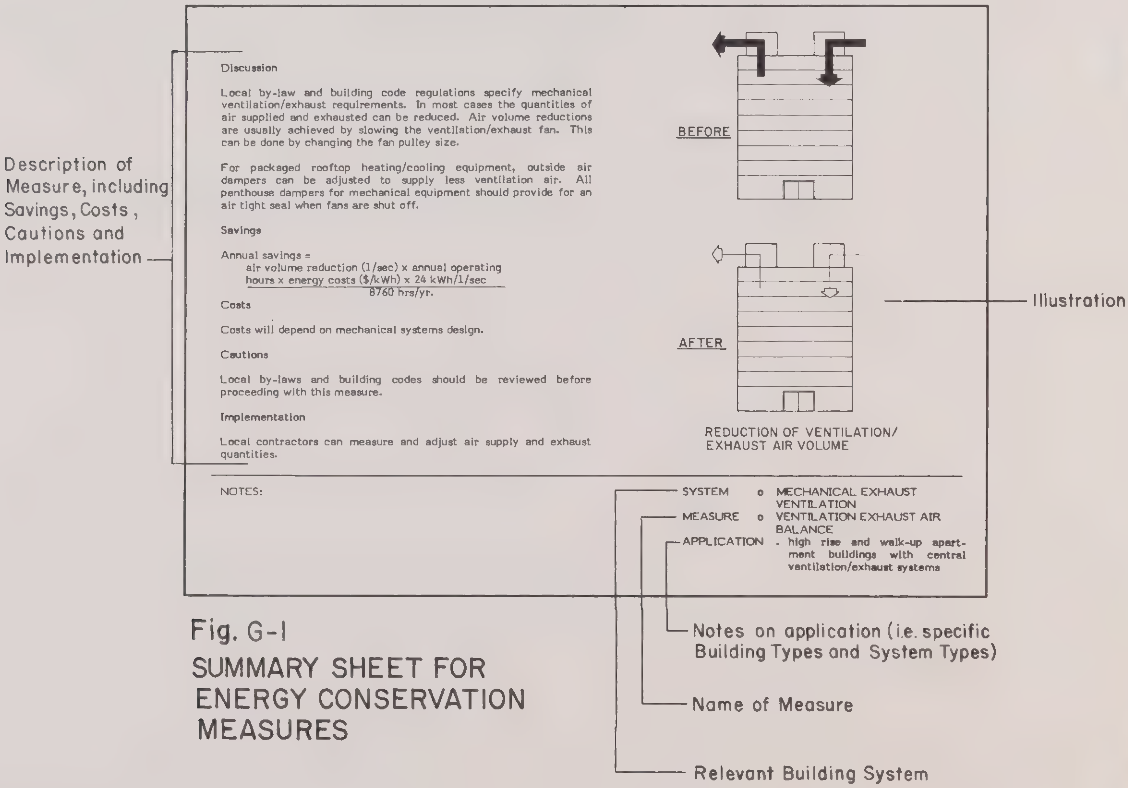


Fig. G-1
SUMMARY SHEET FOR ENERGY CONSERVATION MEASURES

SECTION 6: MAINTENANCE

Considerable energy savings can be achieved through regular maintenance of mechanical systems and the building envelope.

In Section 6 preventative maintenance and its relationship to energy conservation is discussed. Also presented is a "checklist" of maintenance items to ensure efficient building operation.

SECTION 7: TENANTS AND ENERGY CONSERVATION

Tenants, as the primary consumers of energy in multi-unit residential buildings, have an obvious and important role in the implementation of energy conservation measures. Many measures, such as reducing space and water heating temperatures, affect tenant comfort. Other measures, such as the wise use of lights and appliances, must involve tenants directly in order to achieve significant energy savings.

Section 7 describes the role of tenants in energy conservation and provides a checklist of measures for tenant implementation.

SECTION 8: RESOURCES

Section 8 presents a collection of resource materials to assist users of the Manual. Specifically, Section 8 includes a glossary of terms, an annotated bibliography and a summary of relevant government assistance programs.

Comments from users concerning the Property Managers Manual should be forwarded to:

Renovation and Energy Conservation Unit
Ministry of Municipal Affairs and Housing
Queen's Park
Toronto
(416) 965-4073

Comments will be used in improving, updating and expanding the Manual.

ENERGY USE PATTERNS

Many factors affect building energy use. These include:

- weather conditions at the building site
- insulation value of walls and roof
- number and size of windows
- quality and type of windows
- air leakage around windows, doors and other openings
- heating, ventilating and air conditioning systems and their operations
- process activities inside the building such as lighting, hot water and appliances
- patterns of building occupancy and use.

No two buildings are exactly alike. Energy use factors will vary from one building to the next. As a result, each building will have a unique set of energy use characteristics. However, while energy use varies from building to building, general patterns do emerge.

A review of energy use patterns provides helpful background information in preparation for a detailed inspection and analysis of a specific building.

Figure E-1 illustrates a breakdown of energy use in a typical multi-unit building. Normally in Ontario, heating consumes the largest piece of the "energy pie".

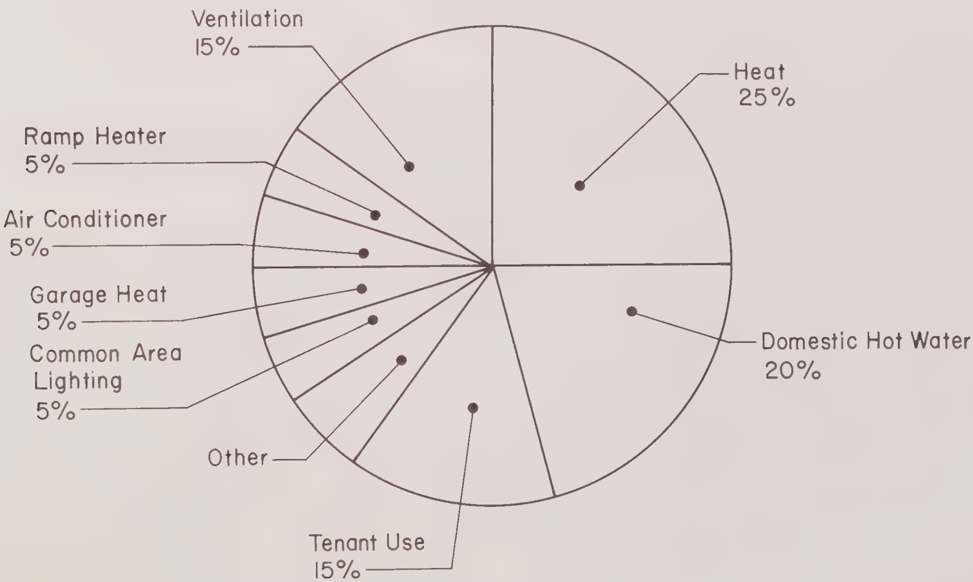


Fig. E-1
ENERGY USE IN A TYPICAL MULTI-UNIT BUILDING

A variety of fuels are used to provide energy for residential buildings:

FUEL	UNITS OF MEASURE
electricity	Kilowatt (kW) Kilowatt hour (kWh)
natural gas	Cubic meter (m^3) Hundred cubic feet (ccf) Thousand cubic feet (mcf)
oil	Litre (l.) Imperial gallon (gal.)
steam	Kilogram (kg.) Pound (lb.)
propane	Litre (l.) Imperial gallon (gal.)
coal	Kilogram (kg.) Pound (lb.)

Each can be associated with specific building systems and an energy use pattern. The major building systems are:

- o heating
- o cooling
- o ventilation/exhaust
- o water supply
- o building envelope
- o lighting
- o appliances

The energy use pattern for each fuel will reflect the number and type of systems using the fuel. For example, the pattern for natural gas use for a typical year is shown in Figure E-2. This natural gas use pattern is typical of buildings with gas-fired furnaces and gas-fired domestic hot water systems.

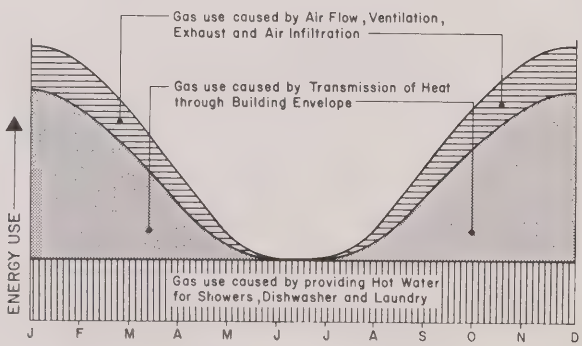


Fig. E-2
NATURAL GAS USE PATTERN FOR A TYPICAL MULTI-UNIT BUILDING

Each fuel will provide a distinct energy use pattern. The individual patterns for all fuels used can be combined to give a composite picture of total building energy use. Figure E-3 illustrates a composite energy use pattern for a typical multi-unit building.

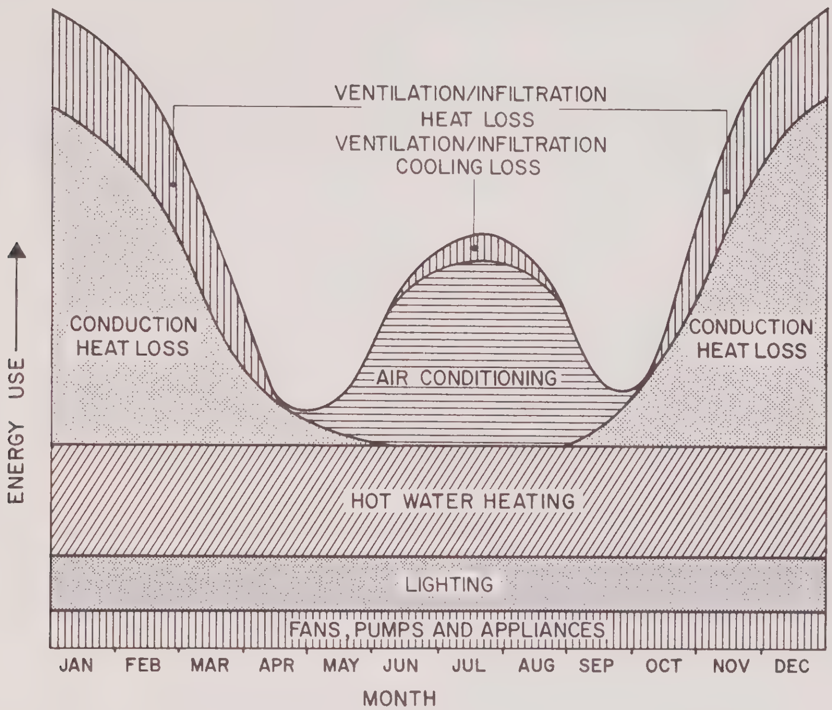


Fig. E-3
TOTAL ENERGY USE PATTERN FOR A TYPICAL MULTI-UNIT BUILDING

Energy use for fans, pumps, lighting and appliances, supplied by electricity, remains fairly constant throughout the year. Domestic hot water heating, typically by electricity or natural gas, also remains relatively steady throughout the year. Energy used for space heating, which can be supplied by any of the energy fuels, represents a major portion of the total energy demand and peaks during the winter months. Conversely, air conditioning, normally supplied by electricity, peaks during summer. Finally, energy use for ventilation and infiltration is, in effect, energy loss through mechanical ventilation/exhaust systems and through air leaks in the building envelope. This energy is in the form of heating energy in winter and cooling energy in summer.

It is important to remember that the same unit of energy can only be saved once. Heating energy consumption, for example, includes a certain proportion of "excess" energy that can be eliminated by various conservation measures. However, total energy savings will not necessarily equal the sum of the potential savings of each measure independently. For example, if insulation is estimated to reduce consumption by 20%, air sealing is estimated to save 20% and improved boiler efficiency is also estimated to reduce consumption by 20%, the application of all three measures will not necessarily yield a 60% reduction. There may not be 60% excess energy use in the building. Ideally, total potential savings are estimated, and only the most cost effective means of achieving those savings are chosen.

READING ENERGY BILLS

An understanding of energy pricing and billing is necessary to enable realistic evaluations of energy conservation measures.

1. Oil, Propane and Other Transportable Fuels:

Prices and billings for fuels such as oil are straightforward. In general, the fuel is sold at a single price per unit. For example, in most parts of Ontario fuel oil sells for about $0.30 per litre (1982). Oil bills simply record the grade of fuel oil purchased, the price per unit, the number of units purchased, and the total purchase price. The total purchase price is arrived at by multiplying the unit price by the number of units consumed.

2. Natural Gas:

Natural gas pricing is based on a declining block rate structure. Several categories of consumption levels are established. Higher consumption categories have lower per unit gas prices. An example of natural gas rates applicable to large residential buildings is shown below (Consumer's Gas Co., May, 1983):

First 14000m^3 or less per month	\$0.180162 per m^3
Next 28000m^3 per month	\$0.175729 per m^3
All over 42000m^3 per month	\$0.172470 per m^3

In some cases, rates vary between winter and summer. The rates shown above, for example, apply to the period between November and April. Rates for May to October are slightly reduced.

Rates also vary according to the volume of gas used in the building. For example, the rates shown above apply to buildings that consume over 340,000m^3 of natural gas annually. Buildings using smaller volumes usually fall within the regular residential rate structure that applies to detached homes.

Many multi-unit residential buildings have a standby or alternate fuel source such as oil. In such cases, the building can be provided with "interruptible" service by the gas utility. Interruptible rates are usually established on a contract basis and are set at a single fixed cost per unit.

Natural gas consumption can be monitored by reading meters. Caution, however, should be used in interpreting meter readings since all readings are subject to pressure and temperature corrections to produce accurate consumption figures. Local utilities will advise as to temperature and pressure corrections.

3. Electricity:

Charges for electricity are based on two metered values:

- kilowatt-hours (kWh) of electricity consumption
- kilowatts (kW) of electricity demand

Figure E-4 illustrates an electricity meter.

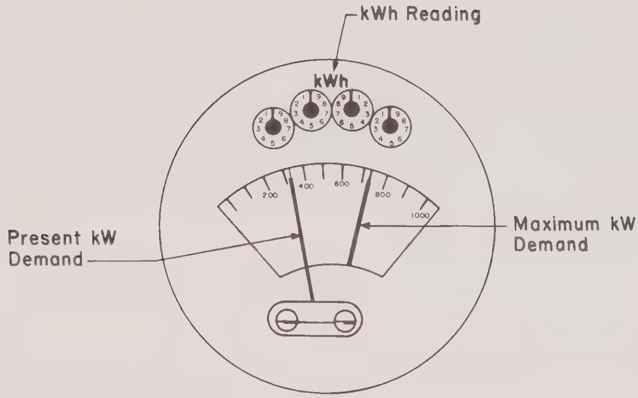


Fig. E-4
ELECTRICITY METER

The kilowatt-hour meter measures energy consumption cumulatively. This component of the bill is based on the total consumption for one month. In many cases, a declining block rate structure is used.

The kilowatt meter (demand meter) measures the average demand over a short period of time (e.g. 20 minutes). This component of the bill is based on the maximum demand for the month. There is a price per unit of demand (kW). At the end of the month the demand meter is usually re-set to zero. Smaller buildings do not have demand meters.

The total electricity bill is a combination of the consumption charge plus the demand charge. In smaller buildings with no demand meter, the bill is based on the consumption charge only.

Electricity rate structures vary from municipality to municipality. Rates should always be checked before selecting energy conservation measures, since they can have a major effect on the feasibility of those measures that reduce electricity use.

Some examples will illustrate:

In the City of Toronto, 1982 Commercial/Industrial electricity rates (applicable to bulk metered multi-unit buildings) are:

Demand charge applied to monthly billing demand	$2.91/kW
First 100 hours use of the monthly billing demand	0.0612/kWh
Next 100 hours use of the monthly billing demand	0.0268/kWh
Remaining kilowatt hours	0.0164/kWh
Minimum monthly bill	$5.00 gross

(Note: Rates listed assume 10% discount for prompt payment.)

With this rates structure, energy used during the peak demand periods is much more expensive than energy used off-peak. A reduction of 1 kW of demand during the peak saves costs in two ways:

- $2.91 per month is saved directly from a 1 kW reduction in the demand charge.

- Reducing peak demand has the effect of moving kWh of consumption from peak periods (where they are expensive) to periods of low-demand (where they are inexpensive). This produces savings in the consumption part of the bill. The amount saved is the difference between the price of kWh during the peak, and the price of kWh off-peak. A 1 kW reduction in demand over the first 100 hours of demand period saves:

  100 hrs. X (cost/kWh for first 100 hours - base cost/kWh)
  = 100 hrs. X ($0.0612 - $0.0164)
  = $4.48/kW

  This same 1 kW reduction for the second 100 hrs. of demand saves:

  100 hrs. X (cost/kWh for second 100 hrs. - base cost/kWh)
  = 100 hrs. X ($0.0268 - $0.0164)
  = $1.04/kW

  The 1 kW reduction after the second 100 hrs. saves nothing; the kWh cost is now equal to the base kWh cost.

Total savings per month from a 1kW reduction in demand are:

Demand charge	$2.91
Consumption savings (1st 100 hrs.)	4.48
Consumption savings (2nd 100 hrs.)	1.04
Total	$8.43

Rates in the City of North York present a very different situation. Commercial/ Industrial monthly rates for May, 1982 are:

1st 50 kW of demand	N/C
Balance of demand	$2.60/kW
1st 250 kWh consumption	0.048/kWh
2nd 9,750 kWh consumption	0.0404/kWh
3rd 2,000,105 kWh consumption	0.0275/kWh
Balance	0.0145/kWh
Minimum Billing	$4.50

A 1 kW reduction in demand saves $2.60 per month if demand exceeds 50 kW. Otherwise, it saves nothing.

The price per kWh will be an average cost, including 4.8¢/kWh for the first 250 kWh, 4.04¢ for the second 9,750 kWh, and 2.75¢ for the 3rd 2,000,105 kWh. (Consumption levels in the order of 2 million kWh/month are found only in major industrial uses; no multi-unit building will take advantage of the 4th block.)

Comparing Toronto and North York rates illustrates a fundamental consideration in energy management.

In Toronto, a 1 kW reduction in demand will save $8.43/month. In North York, the same 1 kW reduction will save only $2.60. Measures that save electricity during the peak period will obviously be much more attractive in Toronto.

The base consumption rate in North York will average generally around 2.75¢/kWh. The base rate in Toronto is only 1.64¢/kWh. Measures that save electricity off-peak (e.g. turning off air conditioners at night) will generate much more savings in North York.

Peak Load Control

The practice of transferring electrical energy use from peak demand periods to off-peak periods is called **peak-load shedding.**

Electrical energy demand comes from many sources. Peak load shedding typically involves turning one or more of these demand loads off during peak periods.

Sources that can be shut off are those that do not severely affect building operations or comfort levels. Examples are water heating systems, automobile block heaters and, in special cases, space heating systems, ventilation equipment and large motors. (Note: Large motors should not be shut off for periods of less than 2 hours; frequent on/off cycling increases wear.)

The simplest load controller is a time clock. If demand periods are predictable and consistent, equipment can be timed to shut off in regular cycles. A 7-day timeclock typically costs about $250.00. Special demand controllers measure demand levels in kW and automatically shed and restore loads in a pre-set sequence. A variety of these devices are commercially available. Assistance from a specialized consultant may be needed to evaluate the cost-effectiveness of demand controllers in a particular building. Demand controllers range in price from $3,000.00 to $5,000.00.

An alternative to shedding electrical loads is to change fuels. Electric hot water systems and laundry dryers, for example, can all be converted to natural gas. In certain cases, a conversion may eliminate a major electricity user from the peak demand period.

Savings achievable through demand control will depend largely on local utility rate structures. In Toronto, for example, a 100 kW peak demand reduction would save annually:

100 kW X $8.43/kWh X 12 months = $10,116.00.

The same 100 kW reduction in North York would save annually:

100 kW X $2.60/kWh X 12 months = $3,120.00.

APPROACHES TO ENERGY CONSERVATION

Energy conservation can be approached in two distinctly different ways. One is the **random approach**, whereby conservation measures are selected and implemented more or less randomly as they are available, affordable or convenient. The other is the **energy management approach**, whereby specific measures are selected, implemented and monitored as part of a comprehensive, long-term strategy. Energy conservation becomes an integral part of overall property management.

These two approaches are outlined in Figure M-1 (opposite) and compared below.

Random Approach:

Advantages:

- fast and direct
- little preparation required
- implementation carried out directly by staff or contractors

Disadvantages:

- little information generated about building energy use, energy costs and potential energy savings
- measures selected might not be the most cost-effective
- measures might be implemented in an inappropriate order
- no system exists for monitoring conservation results.

Energy Management Approach:

Advantages:

- information is available to enable selection of most cost-effective measures, and to ensure measures are implemented in an appropriate order
- a monitoring system is established to measure conservation results
- energy conservation becomes part of the overall property management process
- optimum energy conservation results can be achieved.

Disadvantages:

- preparation time is required before implementing conservation measures
- professional consulting services may be required
- staff time will be required for monitoring and review of conservation results.

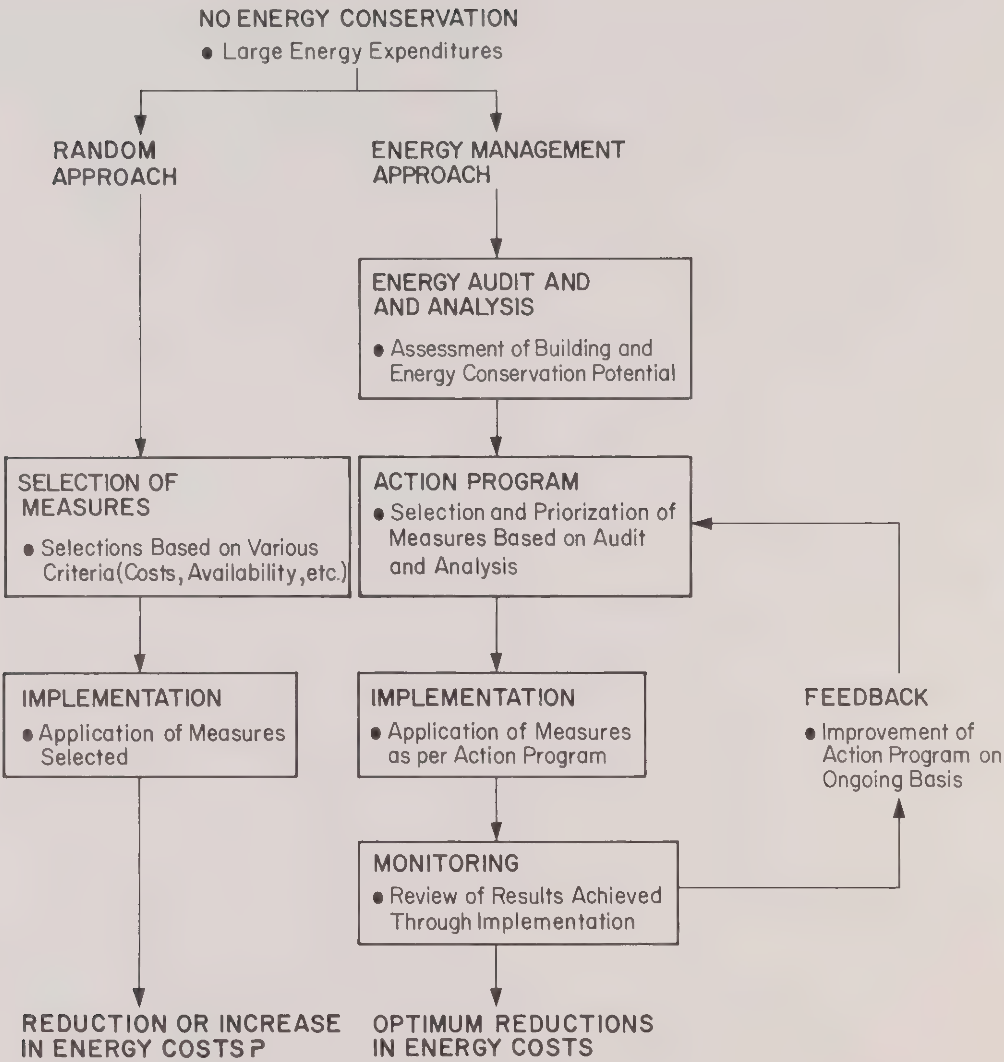


Fig. M-1
APPROACHES TO ENERGY CONSERVATION

Multi-unit residential buildings present a broad and diverse range of opportunities for energy conservation. Various measures can be applied to each building system. Some measures achieve large savings while others have only a marginal impact. Some require little or no capital investment while others are expensive to implement. Measures can be applied alone or in any number of combinations, at once or in stages over time. Given the complex set of options available to the property manager, a well-planned and organized approach is advisable, if not essential.

As noted, the simple random approach provides no clear indication that the most cost-effective measures are selected. Further, the lack of preparation and relevant energy use information presents a risk that measures may cause building system problems or produce disappointing results.

For example, air sealing and insulating a building could produce disappointing results if the heating system is not operating properly and heating system controls are inadequate. Tenants will compensate for the reduced heat loss and warmer apartment units by opening windows and allowing heat to escape.

To be most effective, energy conservation must become a long-term commitment and a fundamental part of ongoing property management. As indicated throughout Section 5 of this Manual, many energy conservation measures require monitoring, experimentation, periodic adjustments and careful tailoring to suit the characteristics of a specific building. These are best implemented within an energy management framework.

The following subsections outline basic energy management methods. These are optional. Users considering an energy management approach should review the methods carefully for potential application. Users already involved in energy management or opting for a random approach, may proceed directly to Section 5.

ENERGY AUDIT AND ANALYSIS

The energy audit and analysis, as identified in Figure M-1, is the first step in an energy management program. It provides vital information for designing an action program, implementing the most cost-effective measures and establishing a system for monitoring energy conservation results.

The energy audit and analysis answers five key questions:

1. **WHAT are the building energy use patterns?**
2. **WHERE is the building using energy; which systems?**
3. **WHY is the building using these quantities of energy?**
4. **WHEN should energy conservation measures be applied?**
5. **HOW can energy conservation be implemented?**

Outlined below are simple techniques for answering these questions for a specific building.

1. **WHAT are the building energy use patterns?**

This question can be answered by reviewing actual energy consumption records. An Actual Energy Use Sheet, illustrated in Figure M-2, can be used to simplify the task of organizing fuel consumption records for analysis.

The Actual Energy Use Sheet covers a twelve month period; a minimum of one calendar year is required for review. Energy use data can be obtained from internal files or utility company records. (See **Reading Energy Bills.**)

Total consumption figures from monthly utility bills are recorded for the appropriate fuel type and month. Monthly totals are then added to give annual consumption values.

Fuel use is converted to the common energy unit of Kilowatt-hours (kWh). Conversion factors for various fuels are listed on the Actual Energy Use Sheet. The total annual consumption for each fuel type is multiplied by the appropriate conversion factor to give total consumption in kWh. Fuel consumption is then added to electricity consumption to give total energy consumption. This figure is then divided by the gross floor area (m^2) of the building. The result is an **energy index** expressed in kilowatt hours per m^2 per year (kWh/m^2/yr.).

The **energy index** provides a basic indicator of existing energy consumption. Calculating the **energy index** each year will enable annual monitoring of total energy consumption. Also, energy indices can be compared from building to building. Most multi-unit residential buildings in Ontario consume from 250 kWh/m^2/yr. to 600 kWh/m^2/yr.

An example of a completed Actual Energy Use Sheet is shown in Figure M-3. In this case, both space and water heating are provided by natural gas, while electricity powers the other building systems. Separate energy indices can be calculated for gas or electricity by dividing independently the subtotals (i.e. electricity consumption in kWh/yr. and gas consumption in kWh/yr.) by the gross floor area.

2. **WHERE is the building using energy; which systems?**

This question is answered by determining the energy use for each building system.

The fuel used by each system should be identified and, if possible, the amount of energy consumed by each system should be estimated. Where one fuel is used exclusively for one system, this is a simple task. For example, in a building using propane for water heating and no other system, energy for the water heating system is determined by converting annual propane consumption to kWh. Typically, however, the patterns are not so simple. In the example shown in Figure M-3, electricity services lighting, appliances and cooling, while natural gas energy provides for space and water heating, and mechanical ventilation/exhaust heat loss. A further breakdown of energy use is difficult and may require professional assistance. However, some important insights can be gained simply by analyzing the completed Actual Energy Use Sheet or by plotting the records on a graph in a format similar to that in Figure E-3.

ACTUAL ENERGY USE SUMMARY FOR 19__

MONTH	ELECTRICITY				FUEL NO. 1 FUEL TYPE ____ UNITS ____				FUEL NO. 2 FUEL TYPE ____ UNITS ____				TOTAL ENERGY COST ($)
	kWh	DEMAND (kW	TOTAL COST ($)	COST PER kWh Col. 4 ÷ Col. 2	QUANTITY	DEMAND (if electricity)	TOTAL COST ($)	COST PER UNIT	QUANTITY	DEMAND (if electricity)	TOTAL COST ($)	COST PER UNIT	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JANUARY													
FEBRUARY													
MARCH													
APRIL													
MAY													
JUNE													
JULY													
AUGUST													
SEPTEMBER													
OCTOBER													
NOVEMBER													
DECEMBER													
TOTAL PER YEAR		X				X				X			

	Annual Consumption		Conversion Factor		Annual Consumption (kWh/yr.)
Total Column 2 Electricity		x	1.0	=	
Total Column 6 Fuel no. 1		x		=	
Total Column 10 Fuel no. 2		x		=	
			TOTAL ENERGY	=	[1]

Building Area ____ m^2 [2] EI = ENERGY INDEX

$$EI = \frac{\text{Total Energy Consumption kWh/Yr.}}{\text{Gross Area}(m^2)} = \frac{[1]}{[2]} = \_\_\_\_\_\ \text{kWh/m}^2\text{/Yr.}$$

CONVERSION FACTORS TO kWh

NATURAL GAS		OIL (no. 2)		COAL		STEAM		PROPANE	
m^3	10.3	imperial gallon	48.1	lbs.	2.6	lbs.	2.9	imperial gallon	32.8
mcf	291.1	u.s. gallon	39.9	kg.	5.8	kg.	6.4	u.s. gallon	27.2
ccf	29.1	litre	10.6					litre	7.2

Fig. M-2 ACTUAL ENERGY USE SHEET

ACTUAL ENERGY USE SUMMARY FOR 1981

MONTH	ELECTRICITY				FUEL NO.1 — FUEL TYPE GAS UNITS mcf				FUEL NO. 2 — FUEL TYPE ___ UNITS ___				TOTAL ENERGY COST ($)
	kWh	DEMAND (kW)	TOTAL COST ($)	COST PER kWh Col. 4 ÷ Col. 2	QUANTITY	DEMAND (if electricity)	TOTAL COST ($)	COST PER UNIT	QUANTITY	DEMAND (if electricity)	TOTAL COST ($)	COST PER UNIT	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JANUARY	162900	480.0	4922	$0.03	5576.9		19624	$3.52					24546
FEBRUARY	168000	453.0	5070	0.03	4724.2		17054	3.61					22123
MARCH	184200	465.0	5636	0.03	5629.8		22466	3.99					28002
APRIL	126000	400.5	3860	0.03	4218.8		17099	4.05					20958
MAY	159900	363.0	4836	0.03	1609.6		6544	4.06					11381
JUNE	150900	396.0	4577	0.03	1268.0		5233	4.07					9810
JULY	172800	390.0	5208	0.03	1021.7		4161	4.07					9369
AUGUST	150300	385.5	4560	0.03	875.4		3567	4.07					8127
SEPTEMBER	152100	408.0	4612	0.03	912.5		3718	4.07					8329
OCTOBER	161100	444.0	4865	0.03	2404.3		9617	4.00					14482
NOVEMBER	156300	460.5	4263	0.03	3010.7		11290	3.75					15553
DECEMBER	216600	529.5	6125	0.03	4554.8		16094	3.53					22218
TOTAL PER YEAR	1961100		58434	$0.03	35824.7		136466	$3.81					194899

	Annual Consumption		Conversion Factor		Annual Consumption (kWh/yr.)
Total Column 2 Electricity	1961100	x	1.0	=	1961100
Total Column 6 Fuel no. 1	35825	x	291.1	=	10425075
Total Column 10 Fuel no. 2		x		=	
			TOTAL ENERGY	=	12386175 [1]

Building Area m^2 30000 [2]

EI = ENERGY INDEX

$$EI = \frac{\text{Total Energy Consumption kWh/Yr.}}{\text{Gross Area}(m^2)} = \frac{12386175\ [1]}{30000\ [2]} = 413 \text{ kWh/m}^2\text{/Yr.}$$

CONVERSION FACTORS TO kWh

NATURAL GAS		OIL (no. 2)		COAL		STEAM		PROPANE	
m^3	10.3	imperial gallon	48.1	lbs.	2.6	lbs.	2.9	imperial gallon	32.8
mcf	291.1	u.s. gallon	39.9	kg.	5.8	kg.	6.4	u.s. gallon	27.2
[illegible]	29.1	litre	10.6					litre	7.2

Fig. M-3 SAMPLE OF COMPLETED ACTUAL ENERGY USE SHEET

For example, in Figure M-3, it is assumed that no space heating is required in summer. Therefore, natural gas use in July or August is for water heating only. Since water heating energy consumption does not vary significantly throughout the year, the July or August reading provides a good indicator of water heating energy consumption in any month. On a graph, this could be represented by a horizontal line similar to that in Figure E-3. Energy consumption for space heating is defined by the natural gas consumed above this level in the winter months.

3. **WHY is the building consuming this energy?**

The answer to this question involves identifying the systems that use the most energy, and the systems that use energy above and beyond what is required for efficient operation. Some systems will be wasting energy. It is important to identify this energy waste in order to determine why the building consumes the energy it does, and to show where savings are possible.

Answers to the previous "WHAT?" and "WHERE?" questions will identify the major energy users and the type of fuel used.

In order to identify excessive consumption, actual energy use must be compared to some standards for energy efficient operation. These standards are expressed in an energy budget. A budget can be established for each building and consists of an optimum energy consumption standard for each building system (expressed in $kWh/m^2/yr.$).

Ideally, an energy budget is based on a thorough analysis of building design and operating factors, usually involving professional assistance.

The Budget Energy Use Sheet shown in Figure M-4 (opposite), however, presents guidelines for establishing a general energy budget. In Figure M-5, the Budget Energy Use Sheet is completed for the same sample buildings as used for the Actual Energy Use Sheet (Figure M-3).

The Budget Energy Use Sheet cannot replace a detailed, accurate energy budget developed for a specific building by professional consultants. Rather, the Budget Energy Use Sheet will give the property manager a good indication of how a particular building performs relative to general standards of efficient building operation, and will assist in identifying those systems that appear to use excess amounts of energy.

Completion of the Budget Energy Use Sheet is a simple procedure. The **conduction loss factor** is first determined using the formula at the bottom of the Sheet. This factor, **the budget guideline** for conduction heat loss, and the **fuel efficiency factor** (also from the bottom of the Sheet) are multiplied together to determine the **energy budget** for conduction heat loss. For each of the remaining systems, the budget guideline is mulitplied by the appropriate fuel efficiency factor to determine the energy budget. All energy budgets are added together to determine **total budget energy use.**

A total budget energy use figure can be compared to the **energy index** from the Actual Energy Use Sheet. An example using the energy index from Figure M-3 shows the difference between actual and budget energy as:

Energy Index	- Total Budget Energy Use	= Potential Energy Savings
413 kWh/m^2/yr. (from Fig. M-3)	- 345 kWh/m^2/yr (from Fig. M-5)	= 68 kWh/m^2/yr.

This difference reflects energy waste and, therefore, potential energy savings. Assuming an average energy cost of \$0.03/kWh, these savings could have an annual value of:

68 kWh/m^2/yr. X \$0.03/kWh = \$2.04/m^2/yr.

Since the sample building has an area of 30,000m^2, this represents total potential annual savings of

30,000m^2 X \$2.04/m^2/yr. = \$61,200.00/yr.

The Budget Energy Use Sheet also shows a fuel budget energy use (determined by adding together all budgets for systems using fuel) and an electricity energy budget use (determined by adding all budgets for systems using electricity). These can be compared with energy indices from the Actual Energy Use Sheet for fuel use (actual fuel use in kWh/yr. ÷ floor area in m^2) and electricity use (actual electricity use in kWh/yr. ÷ floor area in m^2) individually.

Also, whenever actual energy use for a single specific system can be determined, this value can be compared with the energy budget for that particular system.

By going through these comparisons of actual and budget energy use, the property manager can begin to identify target areas where energy waste is evident and energy conservation measures are needed.

4. WHEN should energy conservation measures by applied?

Energy conservation measures should be considered whenever actual energy use exceeds budget energy use.

A comparison of actual energy use with the energy budget will provide a general indication of potential savings.

A detailed building-specific energy budget, prepared by consultants, will provide the basis for detailed savings estimates.

Another method of estimating savings is to review measures outlined in Section 5 of the Manual. The review will reveal potential savings for each measure. Knowledge of basic building characteristics will enable the manager to assess whether specific measures are applicable.

A review of the energy conservation measures in Section 5 will also provide general information on the costs of implementing conservation techniques. Energy audits, outlined below, will provide more detailed cost information. Still further detail concerning costs is obtained through manufacturers' or contractors' estimates.

In any case, the property manager will want to ensure that potential savings compare favourably with costs before applying conservation measures.

figure M-4
BUDGET ENERGY USE SHEET

BUILDING SYSTEM	CONDUCTION LOSS FACTOR (1)		BUDGET GUIDELINE (kWh/m²/yr.)		FUEL EFFICIENCY FACTOR (2)		ENERGY BUDGET (kWh/m²/yr.)
CONDUCTION HEAT LOSS		x	105	x		=	
VENTILATION/EXHAUST/ INFILTRATION HEAT LOSS			50	x		=	
DOMESTIC HOT WATER			45	x		=	
COOLING			10	x		=	
LIGHTING			15	x		=	
APPLIANCES/FANS/PUMPS			40	x		=	
OTHER				x		=	

TOTAL BUDGET ENERGY USE (sum of all budgets)	=	
FUEL BUDGET ENERGY USE (sum of budgets for systems using fuel)	=	
ELECTRICITY BUDGET ENERGY USE (sum of budgets for systems using electricity)	=	

(1) **CONDUCTION LOSS FACTOR (C)** is a measure of heat loss through the building shell per m² of building surface area.

$$C = \frac{(A_{Wall} \times U_{Wall}) + (A_{Roof} \times U_{Roof}) + (A_{Glass} \times U_{Glass})}{\text{Floor Area}(m^2)}$$

$$= \frac{(\boxed{} \times \boxed{}) + (\boxed{} \times \boxed{}) + (\boxed{} \times \boxed{})}{\boxed{}} = \boxed{}$$

where A= surface area in m² and U= heat loss co-efficient=inverse of $RSI = \frac{1}{RSI}$

(2) **FUEL EFFICIENCY FACTOR**

- For systems using NATURAL GAS, FUEL OIL or PROPANE = 1.4
- For systems using ELECTRICITY = 1.0

figure M-5
BUDGET ENERGY USE SHEET

BUILDING SYSTEM	CONDUCTION LOSS FACTOR (1)		BUDGET GUIDELINE ($kWh/m^2/yr.$)		FUEL EFFICIENCY FACTOR (2)		ENERGY BUDGET ($kWh/m^2/yr.$)
CONDUCTION HEAT LOSS	1.0	x	105	x	1.4	=	147
VENTILATION/EXHAUST/ INFILTRATION HEAT LOSS			50	x	1.4	=	70
DOMESTIC HOT WATER			45	x	1.4	=	63
COOLING			10	x	1.0	=	10
LIGHTING			15	x	1.0	=	15
APPLIANCES/FANS/PUMPS			40	x	1.0	=	40
OTHER			—	x	—	=	—

TOTAL BUDGET ENERGY USE (sum of all budgets)	=	345
FUEL BUDGET ENERGY USE (sum of budgets for systems using fuel)	=	280
ELECTRICITY BUDGET ENERGY USE (sum of budgets for systems using electricity)	=	65

(1) **CONDUCTION LOSS FACTOR (C)** is a measure of heat loss through the building shell per m^2 of building surface area.

$$C = \frac{(A_{Wall} \times U_{Wall}) + (A_{Roof} \times U_{Roof}) + (A_{Glass} \times U_{Glass})}{\text{Floor Area}(m^2)}$$

$$= \frac{(\boxed{7500} \times \boxed{1.0}) + (\boxed{1500} \times \boxed{1.0}) + (\boxed{3500} \times \boxed{6.0})}{\boxed{30000}} = \boxed{1.0}$$

where A= surface area in m^2 and U= heat loss co-efficient=inverse of $RSI = \frac{1}{RSI}$

(2) **FUEL EFFICIENCY FACTOR**

- For systems using NATURAL GAS, FUEL OIL or PROPANE = 1.4
- For systems using ELECTRICITY = 1.0

5. HOW can energy conservation be implemented?

A program of energy conservation begins with a detailed energy audit. The audit involves a physical inspection of the building and an evaluation of the applicability and feasibility of specific energy conservation measures.

A number of alternatives are available for the audit:

i) Building Review Using Property Managers Manual:

This Manual can be used as a reference for a building audit. The building **energy index** can be calculated. **Budget guidelines** can be established. Building systems and their operation can be inspected, and **energy conservation measures** can be reviewed for an action program. Contractors can be called to arrange for system modifications.

Advantages:

- o results in immediate energy conservation action
- o provides a learning exercise and a transfer of energy management technology to the user
- o low cost method since no outside consultants are used.

Disadvantages:

- o complex systems may not lend themselves to treatment by documented energy conservation measures
- o existing building personnel may not have time to manage the program
- o problems may develop with contractors

ii) Do-it-Yourself Audit:

The Ministry of Municipal Affairs and Housing has sponsored the development of a Do-It-Yourself Audit for residential multi-unit buildings. The Do-It-Yourself Audit does not apply directly to townhouse or small single family dwellings. The procedure provides an evaluation of building energy efficiency and calculates the potential energy savings.

The Do-It-Yourself Audit method concentrates on the identification of energy savings for mechanical systems within the building: heating, cooling, ventilation, domestic hot water. Envelope measures such as weatherstripping storm windows and adding insulation are not reviewed. An energy use monitoring procedure is also provided.

Advantages:

- o provides documentation as a basis for an action program
- o provides a do-it-yourself monitor system for tracking energy use after the audit

- provides an energy budget
- low cost method

Disadvantages:

- no building envelope measures are reviewed
- requires a time committment to assemble the necessary data for calculations.

iii) Computer Audit/Analysis:

Computer auditing programs are available to calculate the **energy index**, compare the energy index to similar buildings, calculate an **energy budget** and provide recommendations for an **action program**. The programs use data from utility billings and information about the building and its systems. A written report is generated documenting the analysis and recommendations.

Advantages:

- provides documentation as a basis for an action program
- establishes a solid base for a monitor/review system
- provides a detailed energy budget and quantification of savings
- lower cost than the professional site audit.

Disadvantages:

- usually dependent upon information supplied by a questionnaire. Verification of questionnaire data is difficult
- may not provide sufficient information for more complex measures and systems.

iv) Professional Site Audit:

A professional energy consultant makes a visit to the building and reviews building systems and their operation. A written report is generated documenting analysis and recommendations.

Advantages:

- most flexible method
- provides documentation for an action program
- reviews the condition of building systems
- obtains direct feedback from building owner/building personnel
- consultant can organize contractor for implementation of measures
- information is provided to deal with complex systems and measures.

Disadvantages:

- o most costly approach
- o may not establish an energy budget unless called for
- o no monitor/review system built into the process.
- o staff involvement is minimized

ACTION PROGRAM

The energy audit and analysis provides essential information for designing an action program. The action program consists of a list of energy conservation measures, arranged in order of importance and scheduled at appropriate times for implementation. Costs and estimated savings at each stage of the program are included.

Each building will have a unique action program, based on the results of the audit and analysis.

The following general guidelines can be used to assist in the selection and timing of measures.

- o Many low cost or no cost measures are available to produce significant energy savings. These should be considered for the early stages of the action program.

- o In most buildings with excessive fuel consumption, space and water heating controls are a major cause of inefficiencies. Control related conservation measures should be considered for immediate application.

- o For most multi-unit buildings, heating system measures should be implemented along with building envelope measures. Air sealing and insulation, for example, will not achieve expected results if the building remains overheated. Tenants will simply open windows for cooling in winter.

- o Building systems that use large quantities of energy (e.g. heating, water heating) should generally be targeted first for conservation measures.

- o Large differences between actual and budget energy use will reveal buildings and building systems that require immediate attention.

- o It is very important to view all systems of the building together, rather than independently. Each conservation measure should be considered for implications in other building systems.

IMPLEMENTATION

Implementation proceeds according to the action program. Estimates are obtained and contractors are selected for measures that require professional assistance. Notes on implementation for specific energy conservation measures are included throughout Section 5.

MONITORING AND FEEDBACK

The energy audit and analysis, and the action program, will provide the necessary tools and information for ongoing monitoring of conservation results.

An energy index can be calculated each year to indicate annual reductions in overall energy consumption. In addition, actual savings can be compared with savings estimates to assess the success of specific measures.

Weather variations can complicate the monitoring of fuel used for space heating. For example, an accurate comparison of heating fuel consumption for this February with February of last year must account for weather differences. Computer programs are available to make the required adjustments. Computer programs for monitoring energy use also adjust data to account for differences in the length of billing periods.

Monitoring information is extremely important. This information is "fed back" into the energy management process to enable ongoing revisions to the action program. New conservation measures can be added; existing measures can be discontinued or modified.

As information concerning the building energy use characteristics is built up, energy conservation can become more and more effective. Specific system problems will be identified. Measures will be adapted to suit each building.

Over time, optimum energy conservation results will be achieved.

HEATING SYSTEMS

Heating systems generate heat, distribute the heat throughout the building, and maintain specified space temperatures.

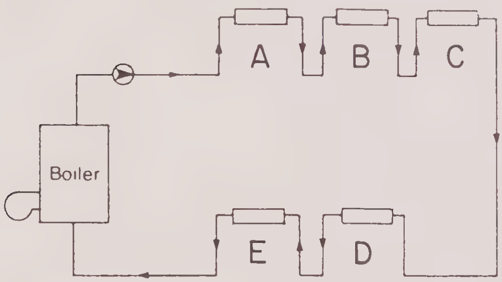
Heating systems present major opportunities for energy conservation. Many systems are currently operating with inadequate controls and/or at far less than optimum efficiency levels. In some cases, heating systems consume twice the amount of energy that is required to heat the building because of control or system problems. Simple modifications can produce major savings.

Heating systems can be classified into four basic types:

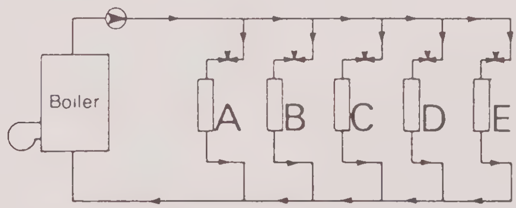
- **Hot Water (Hydronic) System**

  At the heart of the hydronic system is a boiler that generates heat from electricity, or by burning oil, natural gas or another fuel. Hot water is circulated by a pump and distribution pipes to radiators, convectors, or fan coil units. Radiators transfer heat from the water to rooms throughout the building and the water returns to the boiler for additional heat. Typical piping circuits are shown in Figure H-1.

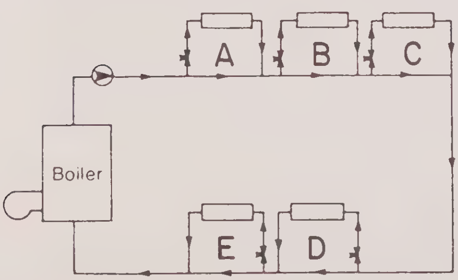
  There are two basic types of space temperature control for hydronic systems - individual control (controls in each space and operated by tenants) and central control (control at the boiler and operated by building staff). Most buildings have central control only, or both central and individual controls.



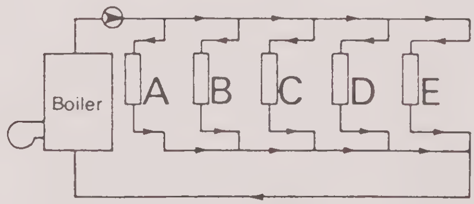
Single-pipe series system



Two-pipe direct-return system



Single-pipe diverting system



Two-pipe reverse-return system

Fig. H-1
COMMON PIPING CIRCUITS FOR HYDRONIC HEATING SYSTEMS
Source: CMHC

Individual control depends on individual control valves at the radiators. The valves are linked to a thermostat in order to maintain the desired space temperature.

With central control, the temperature is often set according to the outside air temperature. As the outside air temperature drops the hot water temperature is increased. "Fine tuning" of space temperatures is often attempted with the adjustment of manual control valves. Overheating and underheating are common with this control method. Tenants are likely to respond to overheating by opening a window, and to underheating by turning the oven on or using an electric heater.

In principle, individual controls permit increased sensitivity to actual heating requirements throughout the building. However, tenants with individual control can and often do maintain unreasonable space temperatures. If central control is used effectively, the relative benefit of individual control is reduced substantially. Measures that improve central control make good economic sense, and, if implemented, can make the economic advantage of adding individual controls marginal.

o Forced Air Systems

Forced air systems are more common in smaller buildings. The furnace uses a small fan to distribute hot air through sheet metal ducts. A return air path is provided to complete the circuit (Figure H-2).

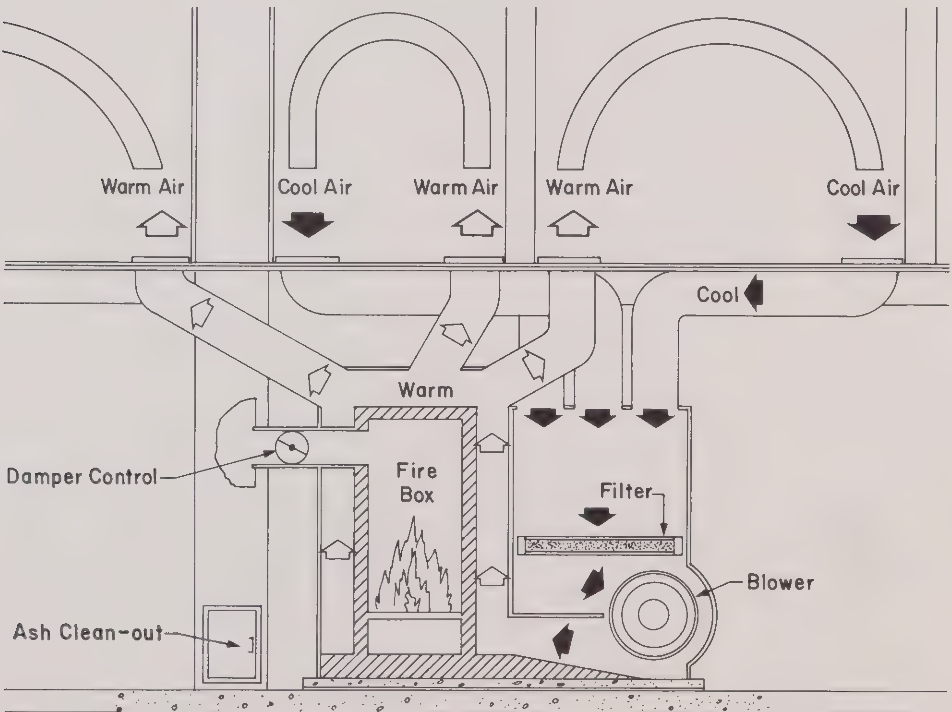


Fig. H2
FORCED AIR HEATING SYSTEM

The control method for this type of system is usually on/off. The furnace fan and combustion cycle are operated in tandem. A thermostat controls the on/off operation.

Individual temperature control for each space in the building is accomplished by adjusting dampers in the air ducts.

- Electric Resistance System

This system does not have a boiler or furnace. Baseboard heating elements or convectors are provided for each building space. Electricity is converted to heat through resistance in a manner similar to an electric toaster. This system has no combustion energy losses or standby energy losses.

Energy for heating is distributed through electrical wiring to wall or baseboard heaters throughout the building (Figure H-3). A thermostat is used in each building space to control heating elements. Individual space heating thermostat controls can be a flexible and effective method of temperature control, provided tenants do not maintain unreasonable temperatures. Electric resistance heating generally is easier to control than the valves and dampers associated with water and air systems.

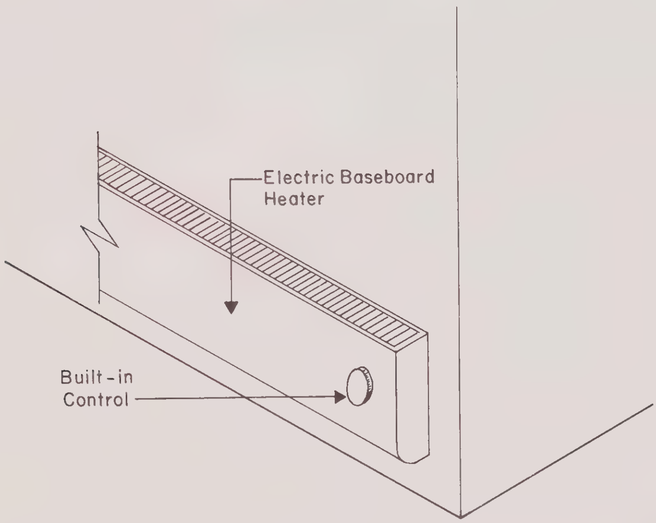


Fig. H-3
ELECTRICAL BASEBOARD HEATING UNIT

Electric radiant panels are sometimes incorporated into the construction of high rise buildings. In most cases, the panels are built into ceilings (Figure H-4).

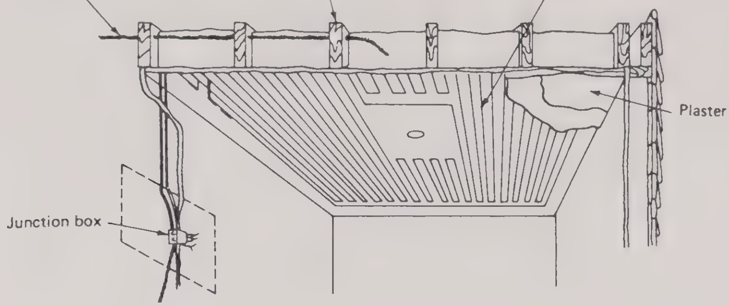
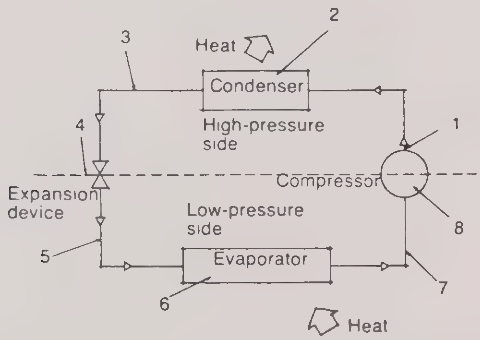


Fig. H-4
ELECTRIC RADIANT HEATING SYSTEM IN CEILING
Source: H.E. Bovay, Jr.
Handbook of Mechanical and Electrical Systems for Buildings

o Heat Pump Systems

A heat pump system may be in the form of a single, independent unit or a network of heat pumps linked together. A heat pump is based on the principle of vapour compression of a refrigerant fluid to produce both heating and cooling. This process is illustrated in Figure H-5.



1. Hot gas leaves compressor at high pressure
2. Hot gas condenses in condenser, giving off heat to surroundings
3. Hot liquid at high pressure
4. Liquid expands
5. Cold liquid refrigerant
6. Liquid refrigerant evaporates, absorbing heat from surroundings
7. Cool low-pressure vapour enters compressor
8. Vapour is compressed

Fig. H-5
VAPOUR COMPRESSION CYCLE
Source: CMHC

Electricity is required to operate the compressor and make the system work. Assuming the compressor performs one energy unit of work, the heat pump cycle typically produces two energy units of cooling (evaporator) and reject three energy units of heat (condenser). The compressor "pumps" two units of energy from a low temperature (evaporator) to a higher temperature at the condenser. The heat rejected at the condenser is the sum of heat extracted from the evaporator (2 units) and the heat produced by compressor work (1 unit).

In winter, heat is pumped into the building using the condenser. The heat pump extracts heat at the evaporator by cooling outside air (air source heat pump) or by cooling water (water source heat pump). In summer, the process can be reversed. The evaporator is used to cool room air while the condenser rejects the unwanted heat outside.

In multiple heat pump systems the heat pumps are connected by a water piping distribution loop. This interconnection allows the heat pumps to trade energy through the water loop. A boiler is used to provide supplementary heating. The cooling tower removes excess heat from the water loop in summer months. (See Figure H-6).

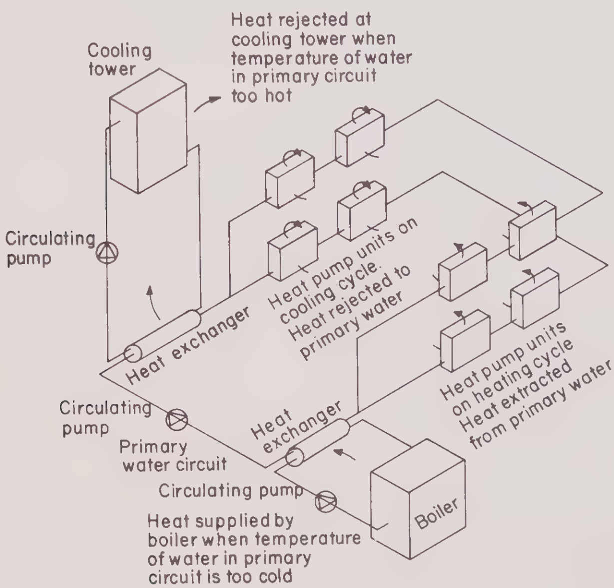


Fig. H-6
MULTIPLE HEAT PUMP SYSTEM
Source: CMHC

Discussion

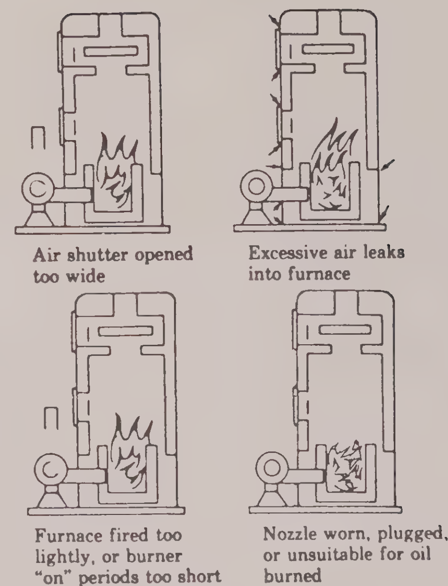
The **combustion efficiency** of the boiler or furnace should be checked and adjusted annually by a trained technician. An annual inspection should include:

General:

- o Inspect door gaskets. Replace them if they do not provide a tight seal.
- o Inspect stacks. Check stack temperature.
- o Inspect linkages periodically for tightness. Adjust when slippage or jerky movements are observed.
- o Observe the fire when the unit shuts down. If the fire does not cut off immediately, it could indicate a faulty solenoid valve. Repair or replace as necessary.
- o Inspect nozzles or cup of oil-fired units. Keep clean.
- o Check burner firing period. If it is improper, it could be a sign of faulty controls.
- o Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks. Keep boiler clean.
- o Check air-to-fuel ratio.
- o Examine operating procedures when more than one boiler is involved. It is far better to operate one boiler at 90% capacity than two at 45% capacity each.
- o Clean mineral or corrosion build-up on gas burners.

Electrical Boilers:

- o Inspect electrical contacts and working parts of relays and maintain in good working order.
- o Check heater elements for cleanliness. Replace as necessary.
- o Check controls for proper operation. Adjust as necessary.



COMMON CAUSES OF POOR COMBUSTION EFFICIENCY IN OIL FIRED SYSTEMS

NOTES:

SYSTEM o HEATING
MEASURE o IMPROVEMENT OF BOILER/FURNACE EFFICIENCY
APPLICATION
. all building types
. all heating system types

Fuel Oil Burners:

- Check and repair oil leaks at pump glands, valves or relief valves.
- Inspect oil line strainers. Replace if dirty.
- Inspect oil heaters to ensure that oil temperatures are being maintained according to manufacturer's or oil supplier's recommendations.

Central Furnace, Make-up Air Heaters and Unit Heaters:

- Keep all heat exchanger surfaces clean. Check air-to-fuel ratio and adjust as necessary.
- Inspect burner couplings and linkages. Tighten and adjust as necessary.
- Inspect casing for air leaks and seal as necessary.
- Inspect insulation and repair or replace as necessary.

Savings

Savings will depend on boiler/furnace condition. A combustion efficiency test, by determining the efficiency before and after adjustments, will help to quantify potential savings.

Boiler or furnace controls should be reviewed together with combustion efficiency to ensure maximum energy conservation results.

Costs

Costs for a heating system tune-up can be obtained from the local utility or fuel supplier.

Implementation

Assistance of a trained heating system technician will be required.

Discussion

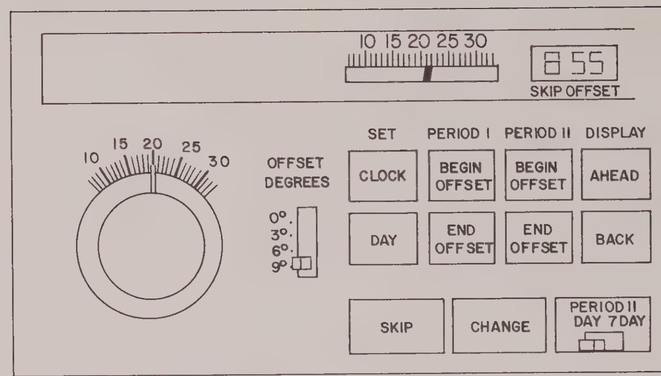
Heating energy consumption is directly related to the difference between interior building temperature and outside temperature. In winter, lower room temperatures mean lower heating energy consumption. Thermostat settings can be set back permanently to a lower temperature, or set back for specified time periods (i.e. night or day setbacks).

The practice of permanent setback is common; many buildings are controlled to the lowest possible temperature. Night or day setbacks are usually directed by some form of automated temperature control, such as **time clocks** or **micorprocessor control systems.** Microprocessor based thermostats are available as replacements for conventional thermostats. Microprocessor or "smart" thermostats can be programmed for day setback and night setback over a 7 day week.

Savings

In most cases, a 1°C permanent setback will save about 5% of the total heating energy consumption, based on a 20°C normal room temperature.

Savings from night setbacks will not be as large since the temperature reduction occurs for only part of the day. Savings also vary from building to building. Well insulated buildings with double glazing benefit less from night setback. In most cases a night setback of 1°C will produce about a 1/2% savings in total heating energy consumption.



MICROPROCESSOR BASED THERMOSTAT

NOTES:

SYSTEM	o	HEATING
MEASURE	o	AUTOMATED TEMPERATURE CONTROL AND NIGHT SETBACK
APPLICATION	.	all building types
	.	all heating systems

Costs

Permanent setback is a no-cost measure. Automated control costs will vary. A "smart" thermostat, programmable for a 7-day period, can be purchased for about $100.00 to $300.00 (1983).

Cautions

Potential savings may not be realized due to heating system control problems. Controls and operations should be checked carefully before proceeding.

Local by-law requirements regarding space temperatures in rental buildings should be checked.

Implementation

Permanent setback is a do-it-yourself measure. Installation of a "smart" thermostat can be a do-it-yourself measure provided the thermostat control wiring is low voltage (24-volt).

Optimum temperature settings for a particular building are usually found through experimentation. Tenant acceptance will be a major factor in determining how low space heating temperatures can be set.

Discussion

In buildings with central hydronic heating systems, boiler water temperature should be kept as low as possible at all times to minimize heat losses through pipes and to avoid overheating.

Systems with central control should be equipped with an **outdoor reset control** which adjusts hot water supply temperature according to outdoor temperature.

Savings

In a building without optimum control, this is a top priority measure that can generate major savings. A general idea of potential savings can be obtained by reviewing the difference between budget and actual energy use as described in Section 4.

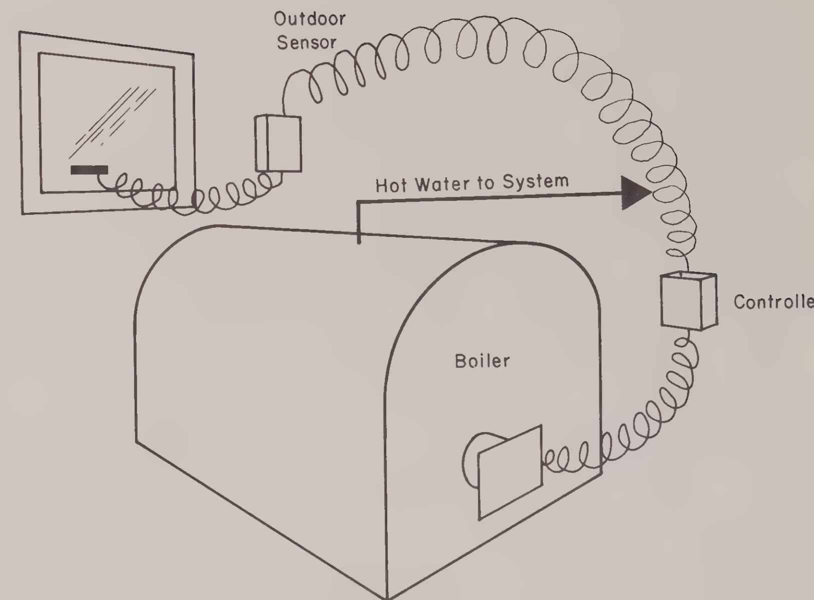
Costs

Costs will vary according to heating system type.

Cautions

Lowering water supply temperature may cause local "cold spots" in the building. Cold spots should be reviewed for infiltration problems (weatherstripping required) and air binding problems in water piping (automatic venting device required).

Reduced boiler temperatures may be inappropriate for systems with stainless steel boilers or with boilers that provide both space and domestic hot water heating.



OUTDOOR RESET CONTROL

NOTES:

SYSTEM o HEATING
MEASURE o OPTIMIZATION OF HOT WATER TEMPERATURE
APPLICATION
- all building types
- hot water (hydronic) heating systems with central control

Implementation

Installation by a mechanical contractor is usually required. At least two contractors should be contacted for cost estimates.

Discussion

A **thermostatic control valve** regulates the flow of hot water to control space temperature. Poorly maintained valves will often malfunction. Field surveys have shown that the control mechanism in faulty valves has often been locked open to provide heating. Although this may avoid underheating in cold weather, it leads to overheating and energy waste in milder weather.

Control valves should be overhauled or replaced as necessary. The overhaul procedure can be scheduled during summer. All valves should be inspected at the same time. The procedure should be repeated every two to three years depending on the age and condition of valves.

Savings

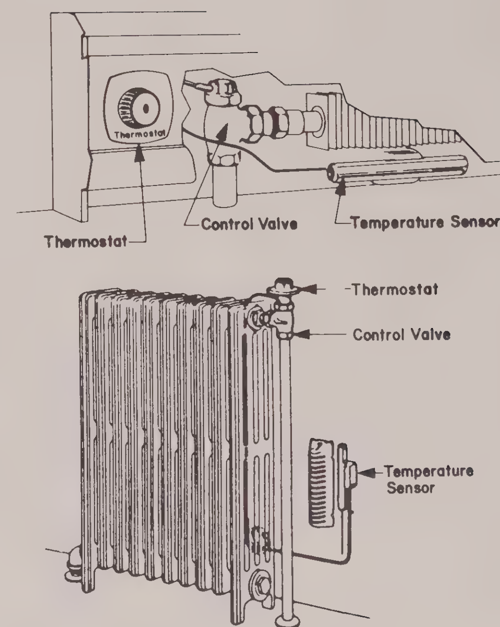
No accurate method can be provided to calculate savings. Energy waste due to control problems is difficult to quantify. A general idea of the savings possible may be obtained by reviewing the difference between actual and budget energy use, as described in Section 4.

Costs

The time required to inspect and/or replace thermostatic control valves averages 2 hours per valve. The cost of replacement valves will vary with the manufacturer.

Cautions

Thermostatic control valve maintenance should be carried out along with central control system maintenance.



THERMOSTATIC CONTROL VALVES
Source: CMHC

NOTES:

SYSTEM o HEATING
MEASURE o OVERHAULING OR REPLACEMENT OF THERMOSTATIC CONTROL VALVES
APPLICATION
- all building types
- hot water (hydronic) systems with direct acting thermostatic valves

Implementation

The assistance of a mechanical contractor is usually required. Contractors can provide estimates for the inspection procedure.

MECHANICAL VENTILATION/EXHAUST SYSTEMS

Small buildings often depend on open windows and the natural infiltration of air through the building envelope to maintain air quality. Many multi-unit buildings, however, have some form of mechanical exhaust or mechanical ventilation system.

- **Mechanical Exhaust Fans**

  Individually or centrally controlled exhaust fans located in kitchen, bathroom and laundry areas are used to expel undesirable odours and excess humidity.

- **Central Ventilation Air Supply System**

  Large buildings may have ventilation air supplied to each floor through a corridor supply system. Volumes of warm inside air must be replaced by cold outside air through infiltration or mechanical ventilation. Ideally, the quantity of exhaust air should balance the supply of ventilation air. A **negative pressure** will develop in buildings where exhaust air quantity exceeds ventilation air quantity. A **positive pressure** will develop in a building if ventilation air quantity exceeds exhaust quantity. (Figure V-1).

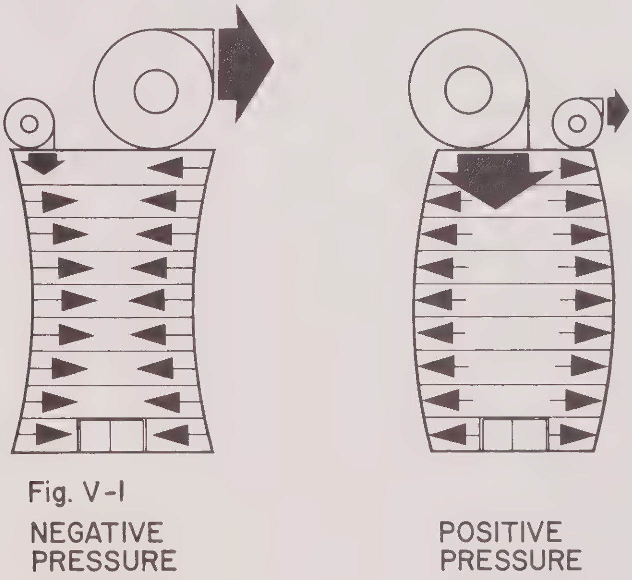


Fig. V-I

Energy is required to heat the supply of cold air brought into the building during the heating season. Energy costs for heating ventilation/exhaust air can be extremely high. The energy required to heat a flow of 1 litre per second of ventilation air, based on continuous operation, in a Toronto-area climate, is 105 kWh/year. At $0.03/kWh, 1 litre/second costs $3.15/year (i.e. 105 kWh/yr. x $0.03/kWh). Typical mechanical ventilation rates for large residential buildings average about 1/2 litre/second/m^2 of gross floor area. The costs of ventilation air heating can then be estimated at $1.57/m^2/year.

Discussion

Local by-law and building code regulations specify mechanical ventilation/exhaust requirements. In most cases the quantities of air supplied and exhausted can be reduced. Air volume reductions are usually achieved by slowing ventilation/exhaust fans. This can be done by changing the fan pulley size.

For packaged rooftop heating/cooling equipment, outside air dampers can be adjusted to supply less ventilation air. All penthouse dampers for mechanical equipment should provide for an air tight seal when fans are shut off.

Savings

Annual savings =

$$\frac{\text{air volume reduction (l/sec) x annual operating hours x energy costs (\$/kWh) x 105 kWh/l/sec}}{\text{8760 hrs/yr.}}$$

Costs

Costs will depend on mechanical systems design.

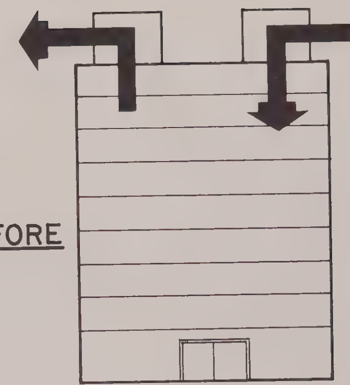
Cautions

Local by-laws and building codes should be reviewed before proceeding with this measure.

Extreme air flow reductions may create operational problems since mechanical ventilation/exhaust systems are designed for a specified minimum air flow.

Extreme air flow reductions may affect interior air quality.

BEFORE



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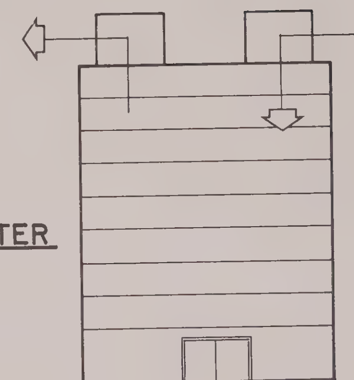


REDUCTION OF VENTILATION/
EXHAUST AIR VOLUME

NOTES:

SYSTEM o MECHANICAL/EXHAUST VENTILATION

MEASURE o VENTILATION/EXHAUST AIR BALANCE

APPLICATION . high rise and walk-up apartment buildings with central ventilation/exhaust systems

Implementation

Local air balancing contractors can measure and adjust air supply and exhaust quantities.

Discussion

Ventilation and exhaust requirements relate to building use patterns. Laundry rooms, for example, are rarely used during the hours between midnight and 7:00 a.m. Mechanical exhausting during this period will not normally be required.

Ventilation and exhaust operation should be geared to various activity periods in the building. Time clocks or other automated devices can be installed to cycle mechanical fans according to activity periods. Most automated control devices provide an on/off control based on a 24 hour clock or similar time based device. Adjustment of the on/off time period can be tailored to suit the specific requirements of the building.

Savings

Annual savings =

$$\frac{\text{operating hrs. saved per yr. (hrs.)} \times \text{energy costs (\$/kWh)} \times 105\,\text{kWh/l/sec} \times \text{fan capacity (l/sec)}}{8760\ \text{hrs/yr}}$$

Savings calculations assume uniform weekly operation of ventilation exhaust. If operation of fans differ between winter and summer, the above caculation should not be used.

Costs

Simple time clocks range in cost from $100.00 to $250.00 (1983).

Savings Example: AUTOMATED CONTROL OF VENTILATION/EXHAUST FANS

Assume ventilation/exhaust operation is reduced from 24 to 14 hr./day. Fan capacity is 10,000 litre/sec. Fuel costs average $0.03/kWh.

Savings =

$$\frac{3{,}650\ \text{hrs.} \times \$0.03/\text{kWh} \times 105\,\text{kWh/l/sec} \times 10{,}000\ \text{l/sec.}}{8{,}760\ \text{hrs/yr.}}$$

= $13,125.00/yr.

NOTES:

SYSTEM o MECHANICAL VENTILATION/ EXHAUST

MEASURE o AUTOMATED CONTROL OF VENTILATION/EXHAUST FANS

APPLICATION . high rise and some walk-up apartment buildings

Cautions

Local by-law and building code regulations should be reviewed before attempting to cycle fans for ventilation/exhaust.

On/off intervals should not be less than 2 hours; otherwise motors may fail prematurely.

Implementation

Exhaust air quantities and ventilation air quantities should be balanced prior to installing automated controls.

MECHANICAL COOLING SYSTEMS

In most multi-unit residential buildings, summer cooling is usually supplied by mechanical fans and open windows. Opening windows at night when temperatures are lower reduces space temperatures. Closing windows during the day, when outside temperatures are warmer, helps to maintain cooler space temperatures.

Mechanical refrigeration equipment or air conditioning systems are used in some buildings to maintain cool space temperatures in hot summer months. Unlike mechanical fans and open windows, mechanical cooling is controlled to maintain specified space temperatures.

Mechanical cooling is provided by a refrigeration cycle. The refrigeration cycle is driven by a compressor powered by electricity. A refrigerant (e.g. freon) is used as a working fluid in the cycle. As the refrigerant is transformed from a liquid to a gas in the evaporator, the heat of vapourization is extracted from the evaporator coils over which room air is circulated to provide cooling. (This process is reviewed under "heat pumps" in the HEATING SYSTEMS sub-section). The refrigeration cycle can be packaged in a number of forms:

- Self-Contained Window Air Conditioner

  The refrigeration cycle is contained within a small self-contained unit that is controlled directly by the tenant.

- Self Contained Reversible Heat Pump

  During summer months the self-contained heat pump acts as a mechanical cooling system (see HEATING SYSTEMS). Individual control is provided for each heat pump.

- Reversible Heat Pump Network

  Heat pumps located throughout the building are linked together by a water pipe system (see HEATING SYSTEMS). Some form of central control is provided.

- Central Chilled Water System

  This system is found in many high-rise buildings (Figure C-1). Water cooled by a central refrigeration machine (chiller) is distributed throughout the building by a water pipe system. A cooling tower removes excess heat from the system. Central control is provided.

Energy used by air conditioning systems will be reflected in electricity billings for summer months. The electricity use (in kWh) will be defined by the energy load (in kW) of the air conditioning multiplied by the hours of operation of the air conditioning equipment.

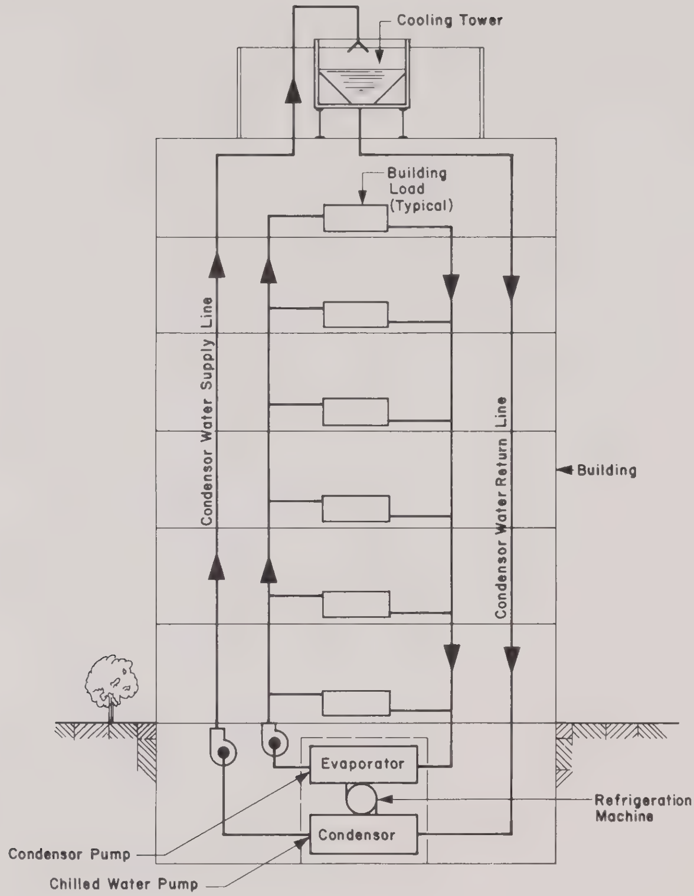


Fig. C-1
CENTRAL CHILLED WATER COOLING SYSTEM

Discussion

Cooling energy can be saved by reducing the hours of operation of cooling systems through the application of automated control. The equipment can be turned off during night hours except for the warmest summer nights.

Timeclocks and similar control devices can be used to control cooling equipment operation. A timeclock can be installed with an outside temperature sensor to provide an override condition. For example, the timeclock may be set to turn off the air conditioning equipment at 11.00 p.m. unless the outside air temperature exceeds 25°C.

Savings

Potential savings can be calculated by multiplying the estimated reduction in hours of cooling system operation by the off-peak electricity costs.

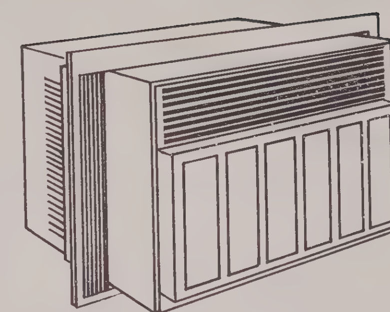
Savings = Cooling load (kW) x reduction in operating hours (hrs.) x electicity costs ($/kWh)

Costs

Costs for automated control vary according to control type and cooling system type.

Cautions

The control of heating and cooling systems should ensure that heating and cooling cycles do not operate at the same time. A reversible heat pump in a townhouse is either in the heating mode or the cooling mode and cannot be in both modes at one time. However, control systems for larger buildings are more complex. Operation of heating and cooling during the milder months of spring and fall should be carefully reviewed.



WINDOW AIR CONDITIONER

NOTES:

SYSTEM MEASURE o COOLING
AUTOMATED CONTROL AND OPERATION OF AIR CONDITIONING EQUIPMENT

APPLICATION
- all building types
- all cooling systems

Implementation

Local contractors can install necessary automated control equipment. Specialized professional advice may be required for larger, more complex systems.

WATER SUPPLY SYSTEMS

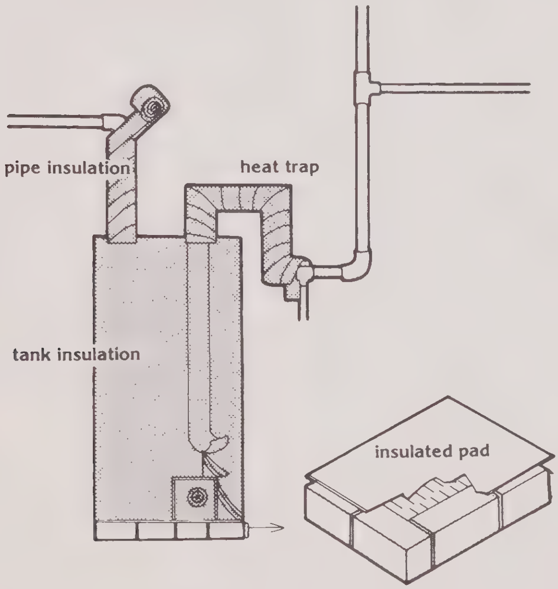
Water supply for a multi-unit residential building involves bringing fresh water into the building from municipal sources, distributing water throughout the building, water heating, and discharging waste water into the local sewer system.

By far, most of the energy required for water supply goes to water heating. This area also presents the greatest potential for energy conservation. There are two basic types of water heating systems:

- Individual Water Heaters

  Individual water heaters for multi-unit buildings are usually standard home water heaters with capacities ranging from 182-273 litres (40-60 gallons). A separate heater is located in each dwelling unit. Heating energy is normally provided by electricity or gas.

  A major advantage of individual water heating is that heated pipe lengths are short, thereby minimizing pipe heat loss.



INDIVIDUAL HOT WATER TANK WITH INSULATION
Source: Ministry of Municipal Affairs and Housing

- Central Water Heating System

  The central system consists of one or more boilers, and one or more large water tanks that supply hot water to the entire building. Most central systems have a re-circulating pump that is used to keep water instantly available to apartment units.

Central systems are less expensive to install in a large building than multiple individual heaters, but are less energy efficient. Central systems have much greater lengths of heated pipe. In most cases only 1/2 of the heat added at the boiler ends up as useful hot water. Also, central systems tend to be much larger than necessary, particularly if flow-reduction devices are used.

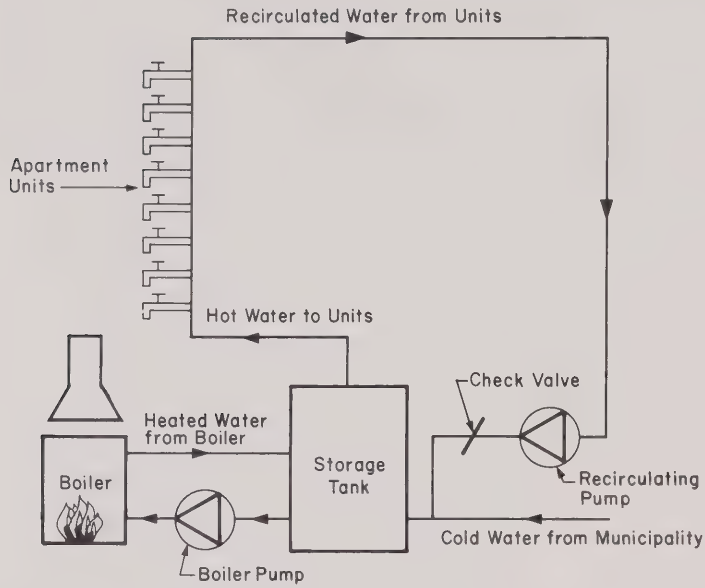


Fig. W-2
CENTRAL WATER HEATING SYSTEM

Water heating systems lose heat year round. The energy conservation measures in this section outline methods for reducing these heat losses. Losses from water heating systems located in heated areas of the building can sometimes provide a useful contribution to space heating in winter. In summer, however, they can add to the air conditioning load.

The costs of hot water production can be reduced through good boiler maintenance. In some cases, it will be cost-effective to replace a boiler with one that is more efficient. In buildings with electric boiler(s), peak load management can provide energy savings.

Reductions in the **volume of water consumed** can generate significant savings. The first, and most effective way to reduce consumption is to fix leaks and drips. A leaking tap can waste well over 4,550 litres (1,000 gallons) of water per year, and the 150 kWh of energy required to heat this volume. The energy conservation measures also describe methods for reducing water consumption.

Discussion

Reducing the stored water temperature saves energy because the amount of heat that is lost from the tank and from pipes is reduced. The **delivered** water temperature should never exceed 60°C (140°F). Temperatures higher than 60°C not only waste energy but also can cause scalding. If there are no dishwashers, the delivered temperature can be reduced to 52°C (125°F) or even 46°C (115°F).

Lower temperatures reduce the effective quantity of stored usable hot water. The tank volume will be used more quickly as less cold water is used for mixing.

Lower water temperatures also tend to reduce scaling in tanks and pipes.

Savings

A tank temperature reduction from 60°C (140°F) to 49°C (120°F) can reduce heat losses by up to 25%. The dollar value of energy saved would vary according to existing heat losses, the percentage of heat losses that provide useful space heat, existing tank and pipe insulation and energy prices.

Costs

Nil.

Cautions

Reducing hot water temperatures may cause tenant complaints.

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o HOT WATER TEMPERATURE REDUCTION
APPLICATION
- all building types
- central and individual water systems

Implementation

Hot water temperatures can be reduced by staff. Temperatures are best reduced incrementally until a lower limit, based on tenant satisfaction, is reached. This limit will vary from building to building and must be determined by experimentation.

Discussion

Domestic hot water **recirculating pumps** usually run continuously, even though they are rarely needed. Recirculating pumps are useful only in the morning, just prior to the start of peak water demand, and throughout the day during periods of low intermittant demand. During periods of high demand there is already sufficient demand. During periods of high demand there is already sufficient flow in the water system. In low rise buildings with short pipe runs, the pump may not be required at all.

The recirculating pump can be shut off permanently or controlled by an automatic timer set so that the pump operates only for specified periods

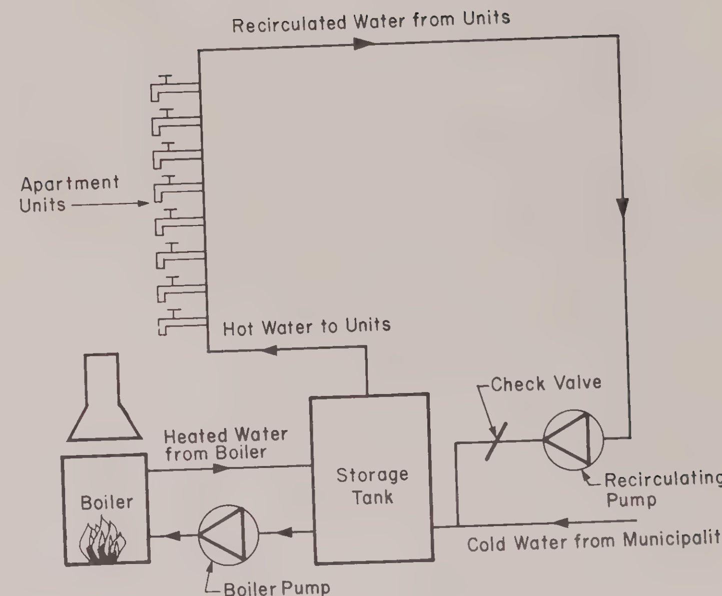
Turning off the re-circulating pump does not stop hot water supply. The only noticable effect may be occasions when taps must run slightly longer than normal before there is hot water.

Savings

Total savings are difficult to estimate. Electrical energy to drive the pump is saved. In addition, heat losses from pipes are reduced, especially at night or when there is very little hot water use. Savings due to the reduction of pipe heat loss can equal as much as 10% of the total hot water energy consumption in large buildings. Savings are greatest when pipes are currently uninsulated and/or pass through unheated spaces.

Costs

Automated timers programmable for a 7-day period range in cost from $100.00 to $250.00 (1983).



CENTRAL WATER HEATING SYSTEM

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o HOT WATER RE-CIRCULATING PUMP SHUT OFF

APPLICATION
- high rise and walk-up apartment buildings
- central hot water systems

Cautions

The **check valve** should be operating properly, or a new valve should be installed on the pressure side of the pump to ensure that cold water is not drawn into hot water lines when the pump is off.

Some systems have both a boiler pump and a re-circulating pump. The boiler pump should not be shut off; otherwise, the system may run out of hot water consistently.

Implementation

Experimentation is required to determine the longest possible shut-off periods.

Discussion

Most individual hot water tanks are insulated. However, the existing insulation may not meet current standards. If the outside of the tank is warm to touch, heat is being lost. Insulation kits are available that provide RSI 1.78 (R-10) fibreglass and an outer layer of vinyl.

All tanks located in unheated areas should be insulated. It may be cost-effective to insulate tanks located in heated areas, although heat lost from the tanks sometimes provides space heating in winter.

Heat traps can also be installed. The insulated inverted elbows prevent hot water from rising into the pipes and siphoning heat away from the tank.

Savings

Installation of an insulation kit typically provides savings of approximately \$15.00 per unit per year (less any useful space heating contribution) (based on 1983 energy prices).

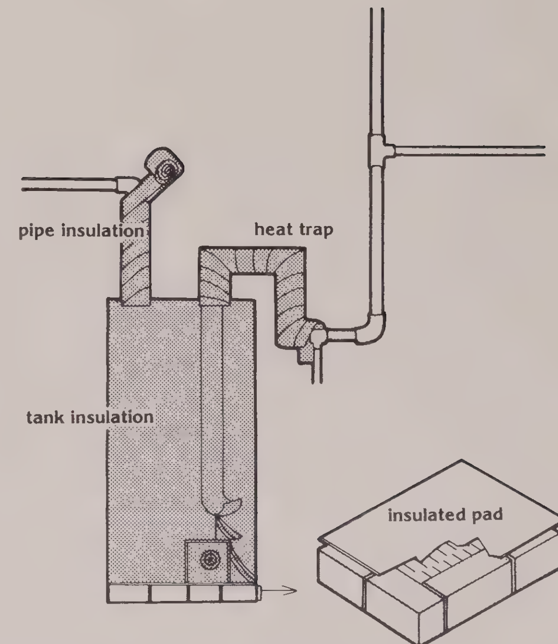
If the water temperature in a tank located in a heated space is reduced to 49°C (120F) or lower, savings by insulating are not attractive.

Costs

Insulation kits cost approximately \$30.00 each (1982).

Cautions

If insulation is added to an electrically heated tank, the supply cable must be rated for 90°C. This can be inspected by an electrician or utility inspector.



INDIVIDUAL HOT WATER TANK WITH INSULATION
Source: Ministry of Municipal Affairs and Housing

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o HOT WATER TANK INSULATION
APPLICATION
- all building types
- individual hot water systems

Controls and combustion air openings should not be covered.

Implementation

Kits are commercially available and can be installed by building maintenance staff.

Discussion

Central domestic hot water systems have large hot water storage tanks. Heat is lost from the tank surface as well as from pipes. The amount of heat loss depends on the water temperature, air temperature, surface area of the tank and RSI-value of existing insulation. Heat loss can be reduced by covering all exposed tank surfaces with insulation.

On older tanks, insulation often shifts over time, leaving the top of the tank exposed. Partial insulation work may be required to ensure all surfaces are covered.

Savings

Doubling insulation cuts heat losses in half. If there is no insulation, the addition of 2" of fibreglass would cut heat losses by approximately 90%.

Potential savings are always greater if the tank is located in an unheated area of the building.

Costs

Costs usually average to approximately $16.00 per square metre of surface area installed (1983).

Implementation

Insulation of a large water tank should be done by professional insulation contractors.

NOTES:

SYSTEM	o	WATER SUPPLY
MEASURE	o	HOT WATER TANK INSULATION
APPLICATION	.	high rise and walk-up apartment buildings
	.	central hot water systems

Discussion

Heat is lost through the surface of hot water pipes running from the tank to the tap. Reducing this heat loss by insulating pipes makes the delivered temperature much closer to the tank temperature. This permits a lower tank temperature and the corresponding energy conservation benefits. (See HOT WATER TEMPERATURE REDUCTION.)

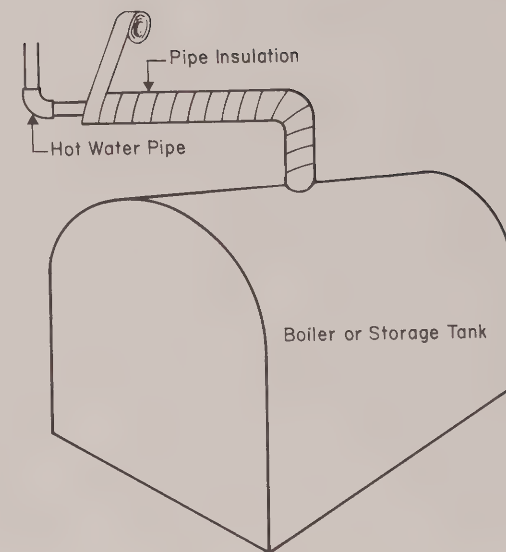
Larger pipes and pipes located in unheated areas (e.g. garages, roof-top boiler rooms) should be insulated first. Pipes located in heated areas may provide some contribution to space heating, but should eventually be insulated as a second priority. Any existing insulation should be inspected. Damaged sections should be repaired or replaced.

Savings

The potential for savings depends on several factors, including surrounding air temperatures, the value of existing insulation, and the contribution of pipe heat loss to space heating and/or air conditioning energy use. The actual savings achieved will vary with each building and each system.

Costs

Pipe insulation costs range typically from $5.00 to $16.50 per linear metre installed (1983).



INSULATION OF WATER PIPES

NOTES:

SYSTEM	o	WATER SUPPLY
MEASURE	o	INSULATION OF HOT WATER PIPES
APPLICATION		. all building types . all hot water heating systems except individual heaters with short pipe runs

Cautions

Heat losses from uninsulated pipes may provide the only space heating in certain otherwise unheated locations of the building. If this heat is used for preventing freezing in nearby cold water pipes, another heat source will be required.

Existing insulation may be asbestos based. All existing pipe insulation should be handled with extreme caution until an insulation specialist verifies content.

Implementation

Pipe insulation may be installed by a specialized contractor, but is also easily done by building maintenance personnel with commercially available products.

Discussion

A **water saving shower head** contains a restrictor that reduces the amount of water flowing through the head. A good quality water saving shower head is designed specifically to give a good shower with less water. Different shower heads should be tested since some are better than others. A restrictor added on to a standard shower head will generally give less satisfactory results.

Savings

A water saving shower head can reduce the volume of water used for showers by one half. This can yield savings of approximately $25.00 per unit per year. Savings will be less in senior citizens buildings.

Costs

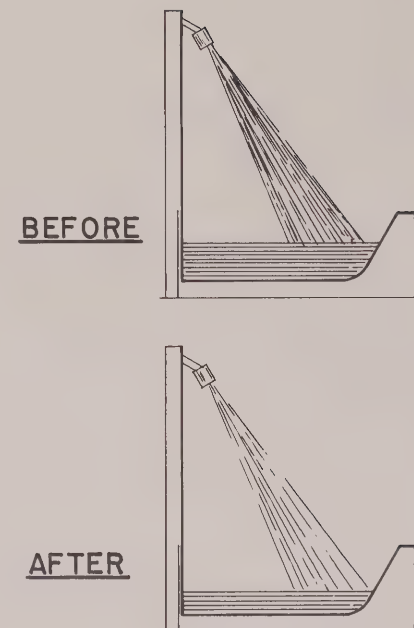
Costs range from approximately $5.00 for an add-on restrictor to approximately $20.00 for a water saving shower head (1983).

Cautions

If system water pressure is low, it may be difficult to achieve a "good" shower. Water saving heads may, however, improve "end-of-line" pressure problems.

Water saving shower heads may cause cross-overs between hot and cold water lines in some high rise buildings.

Some water saving shower heads may require a higher water supply temperature.



INSTALLATION OF WATER SAVING SHOWER HEAD

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o WATER SAVING SHOWER HEAD
APPLICATION
. all building types
. all water systems

Some water saving shower heads "look" radically different than conventional heads and will therefore tend to generate tenant complaints.

Implementation

Water saver shower heads are commercially available and can be installed by existing staff.

Savings Example: WATER SAVING SHOWER HEAD

Assume standard shower head with a 0.38 litre per second (l/s) flow is replaced by a water saving shower head with 0.16 l/s flow.* The shower is an apartment unit where two people, each taking one five-minute (300 second) shower per day.

flow reduction	=	0.38 l/s - 0.16 l/s
	=	0.22 l/s
water saved	=	0.22 l/s x 300 sec. x 2/day x 365 days
	=	48,180 l/yr. x 0.044 kWh/l**
	=	2120 kWh/yr.
Dollars saved	=	2,120 x $0.02/kWh
	=	$42.40 per year per apartment

* flow can be measured by turning shower on full, measuring into a bucket and timing with a stop watch.

** energy required to heat 1 l from 7°C (municipal temp.) to 37°C (shower temp.)

Savings from local water rates are additional.

Discussion

The flow of water through a standard bathroom or kitchen faucet ranges typically from 0.38 to 0.45 litres per second (l/s) (5.0 to 5.9 gallons per minute (gpm)). Installing an aerator with water saving flow restrictor reduces this flow to 0.23 l/s (3.0 gpm).

Savings

Installing an aerator could save 25% of the water used at the sink. Assuming some of this water is heated, dollar savings could average approximately $5.00 per unit per year.

Costs

The average cost per aerator is $2.00 to $3.00 (1983).

Cautions

It is important to repair any leaks or drips when aerators are installed. Savings achieved through such repairs can often exceed those resulting from the installation of aerators.

Water restrictors may cause cross overs between hot and cold water lines in some high rise buildings.

Implementation

Aerators are commercially available and easy to install.

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o WATER SAVER FAUCET
APPLICATION
- all building types
- central and individual hot water systems

Discussion

There are two types of devices that restrict the quantity of water used for each toilet flush. **Toilet dams** are barriers that, when pressed into place on each side of the tank, reduce the volume of water in the tank. **Weights** are used to prematurely close the flush valve. In hard water areas, toilet dams have an advantage in not having moving parts.

Savings

Savings of 9 litres (2 gallons) per flush can be achieved in toilet tanks that hold 23-27 litres (5 to 6 gallons).

If water consumption is not metered, no cost savings are possible.

Costs

Average cost per toilet is $5.00 - $10.00 installed (1983).

Cautions

Toilet dams or weights should not be used where the building has a history of clogging drain pipes.

This measure should be tested first. Some toilets do not flush properly with dams or weights.

Implementation

Toilet dams and weights are simple, commercially available devices for easy installation by staff.

Savings Example: WATER SAVER WATER CLOSET

Assume installation of water saving devices saving 9 l. per flush in a Toronto building with 250 tenants, each using four flushes per day.

water savings	=	9 l x 4 flushes/day x 250 persons x 365 days/yr.
	=	3,285,000 l/yr.
Dollar savings	=	3,285,000 l/yr. x $0.0002945/l*
	=	$967.00/yr.

* Based on City of Toronto rate: $1.19 + 13% (sewage) per thousand gallons.

NOTES:

SYSTEM o WATER SUPPLY
MEASURE o WATER SAVER WATER CLOSET
APPLICATION
. all building types
. all water supply systems

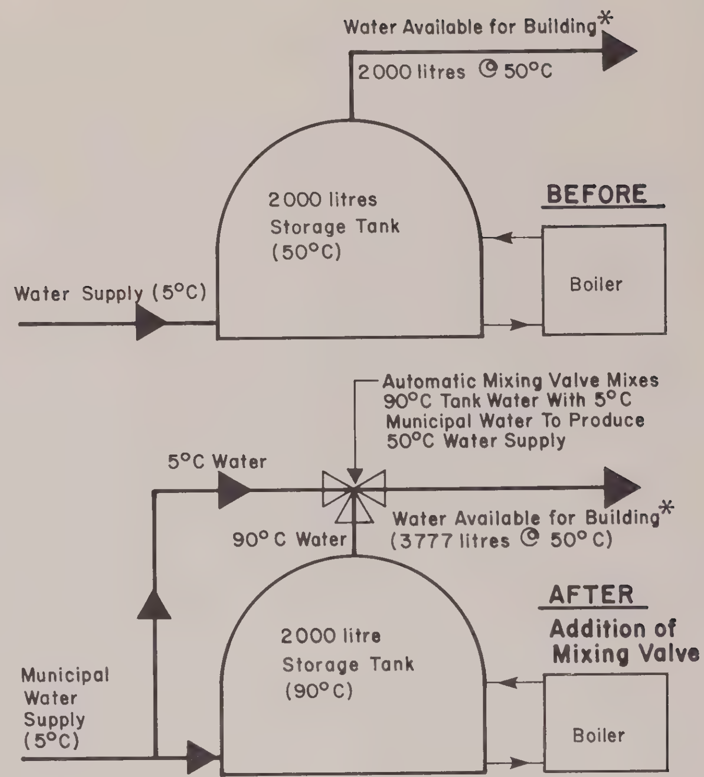
Discussion

Water heating is the most commonly shed energy load in a conventional multi-unit building (See Peak Load Control, Section 3). This load is shed by turning off the water heating energy input during peak demand periods. The amount of peak energy demand that can be saved will vary with the size and type of water heating system, and the occupancy of the building. For example, senior citizens buildings have a relatively low peak per unit as tenants tend to spread hot water use throughout the day. Buildings with "9 to 5" tenants will have very pronounced morning and evening hot water peak demand periods.

The storage capacity of the hot water system also influences the amount of peak reduction possible since it determines the amount of time that heat energy input can be turned off before the water runs cold. Most existing hot water tanks are oversized and will allow for considerable shut-off periods. Measures that reduce hot water consumption will also increase the time that the hot water heater can be shut off.

Useful storage capacity can be increased by raising the tank temperature and installing a mixing valve in order to provide a lower delivered water temperature. This will, of course, increase heat losses through the tank and pipes. These losses, however, may be slight in comparison with the possible reduction in demand charges.

Re-piping existing boilers and/or adding heating capacity to reduce re-heating time after the peak period shut-down will also improve storage utility.



ADDITION OF MIXING VALVE TO INCREASE HOT WATER STORAGE CAPACITY

*Ignores Storage Utility Factor

NOTES:

SYSTEM o WATER SUPPLY

MEASURE o HOT WATER PEAK LOAD CONTROL

APPLICATION
- central hot water systems
- electric buildings

Control for turning water heating energy input on and off range from simple timers (used if the periods of peak demand are consistent and well-defined) to sophisticated controllers that reduce heat input gradually in steps as the peak demand rises, and restores heat input gradually as demand falls.

Savings

Energy savings vary from building to building according to system type and occupancy patterns. Dollar savings vary greatly with local utility rate structures.

Costs

Costs vary according to specific system modifications required.

Cautions

The performance of the existing water supply system should always be reviewed carefully to identify correctable problems before any changes to the system are made.

The advice of professional consultants is required to determine savings, especially for complex systems.

Implementation

Consultants' advice will normally be required to determine the best approach for each building.

Experimentation and "fine-tuning" will be required to achieve the best demand control patterns for each building.

BUILDING ENVELOPE

The building envelope is a system consisting of the roof, floor, walls, windows, and doors - all parts of the building that enclose the interior building space and separate it from the outdoor climate.

The quality of the building envelope is a major factor in the determination of the amount of energy required for space heating or cooling.

Energy to heat interior spaces (in winter) or to cool interior spaces (in summer) is lost through heat transfer and infiltration/exfiltration.

Heat transfer refers to the movement of heat through walls, roof or floors whenever there is a difference between the exterior temperature and the interior temperature. Heat transfer occurs through three natural processes: convection, conduction and radiation.

- o **convection** is the transfer of heat by air in contact with solid surfaces. Cooler air moving over a warmer surface picks up heat, carries it and transfers it to a cooler surface.

- o **conduction** is the transfer of heat directly through a solid surface (e.g. wood, brick, drywall, etc.).

- o **radiation** is the transfer of heat through space. A warm solid surface radiates heat into a cooler space.

Infiltration/exfiltration refers to the flow of air through cracks and holes in the building envelope when there is a difference between external and internal air pressures. Air normally moves from high pressure (warm temperature) areas to low pressure (cool temperature) areas. Two natural processes affect the rate and amount of infiltration/exfiltration.

- o **stack effect.** During cold weather, warm air rises to upper levels where it leaks out to colder outside air (exfiltration). The air lost at the top is replaced by cold air which leaks into the building at the bottom (infiltration). The rate of infiltration/exfiltration depends on the height of the building, the difference between exterior and interior temperatures, and the air tightness of both the building envelope and the interior partitions. If a completely air tight barrier were placed halfway up the building, two independent stack effects would result. This is referred to as "local" stack effect.

- o **wind effect.** Wind affects the rate of infiltration as it passes over a building by creating positive pressure on the windward side and negative pressure on the leeward side. The rate of flow depends on the geometry of the building, the strength and direction of the wind and the air tightness of the exterior walls and interior partitions.

Stack effect and wind effect are illustrated in Figure B-1.

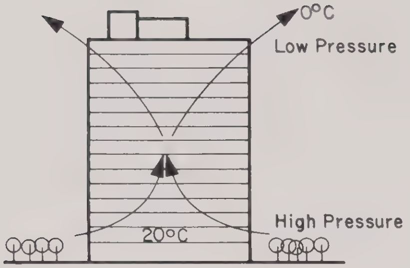
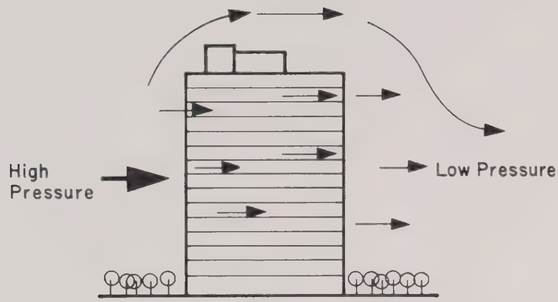


Fig.B-1
STACK EFFECT

Source: CMHC



WIND EFFECT

There are two basic approaches to saving energy through modifications to the building shell:

- **improving thermal performance** by adding insulation to the roof, walls or floor, or by adding double or triple glazed windows. This reduces energy lost through heat transfer.

- **reducing infiltration/exfiltration** by air sealing, weather stripping or adding better fitting windows and doors.

In general, air sealing and other measures which reduce air infiltration/exfiltration should be done before adding insulation. In most cases, air sealing and related measures are more cost effective. Often it is difficult or impossible to air seal after insulation has been installed. Also, air sealing stops warm, moist air from leaking into wall and attic cavities where it cools and condenses, leaving moisture that can corrode or rot building materials. Common signs of moisture damage include brick spalling, efflorescence (white, chalk-like stains on the brick or block), mortar joint erosion, and excessive paint peeling on exterior wood siding. If a building has spots where plaster or drywall always need repair, air leakage and condensation, rather than a water leak, may be the cause.

Many energy conservation measures for the building shell are expensive and difficult to justify, if assessed independently and only in terms of energy costs and benefits. However, the measures may present effective solutions to serious building damage and eliminate uncomfortable drafts and cold spots in a building. Also, insulation and air sealing can be very cost effective when done in conjunction with a major building repair (e.g. roof replacement, foundation water proofing, etc.).

Discussion

Air leakage through the building envelope may be responsible for up to 40% of the total heating requirement of a low rise building.

In addition to windows and doors, leaks occur at sill plates, window and door frames, electrical outlets, attic hatches, penetrations such as bathroom vents and stacks, partition wall/ceiling joints, and fireplaces. Sealing these joints can save energy, eliminate drafts, and minimize potentially damaging moisture build-up in walls and ceilings

Air sealing typically requires:

- o **weatherstripping** windows, doors and other openings (see WEATHERSTRIPPING measures).
- o **caulking** around door and window trim, behind and along baseboards and along other surface cracks.
- o **foamed in place urethane** at basement sill plates, in attics, at wall junctions, electrical wiring penetrations, plumbing stacks, etc.
- o **gaskets** behind electrical outlet plates.

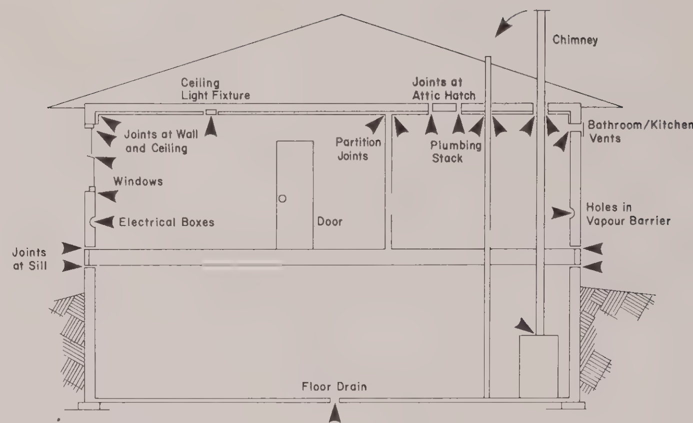
Air sealing is done from the interior of the building.

Savings

Potential savings are difficult to estimate since they depend on specific leakage characteristics. The payback for air sealing work is typically less than 5 years.

Costs

Costs vary with the scope of the work to be done. Labour is the major cost factor.



COMMON AIR LEAKAGE POINTS IN LOW RISE CONSTRUCTION
Source: CGSB

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o AIR SEALING LOW RISE BUILDINGS
APPLICATION . low rise buildings such as townhouses and some walk-up apartment buildings

Cautions

The heating system must be adjusted to suit the reduced heating requirement resulting from air sealing. Otherwise, maximum energy savings will not be achieved.

If the air sealing is thorough, it is possible that interior humidity levels may become excessive and cause window condensation and even mould growth. In addition, interior air quality may deteriorate. If this occurs, additional ventilation is advisable. Advice should be sought from a source experienced in mechanical ventilation.

Implementation

Air sealing can be done by existing building personnel or by air sealing contractors.

Combined approaches are common. The contractor completes difficult air sealing tasks and in-house personnel, with some training, can complete the remaining work.

Many specialized contractors use **depressurization fans** as an effective tool for identifying leakage locations.

Air sealing should be done in conjunction with or before adding insulation.

Further information is provided in "First Seal Your House," and "Caulking and Weatherstripping" prepared by the Ministry of Municipal Affairs and Housing.

Discussion

Air sealing methods for high rise buildings are similar to those for low rise buildings. (See AIR SEALING: LOW RISE BUILDINGS.) The opportunity for savings however, is not as great since sealing is usually limited to exterior walls.

Brick deterioration, indicated by brick spalling, motar joint erosion and efflorescence (i.e. white, chalk-like stains) may be caused by excessive air exfiltration. Interior air sealing around window frames, door frames, and baseboards is desirable.

Since air leakage points vary from building to building, a depressurization test using door fan equipment may be useful in identifying exactly where air leaks are located. In a high rise building, this test is performed by isolating one unit at a time. The test should be performed on a cold day so that air coming in from outside can be detected, as opposed to that coming from adjacent units.

Refer to WEATHERSTRIPPING HIGH RISE BUILDINGS for further information regarding weatherstripping techniques.

Savings

Energy savings vary greatly due to variations in construction quality from building to building.

Costs

Costs vary greatly depending on the specific work required. Air sealing is labour intensive.

Caulk	Life	Moving Joint?	Paintable?	Adhesion to Different Surfaces?	Cost	Notes
Acrylic Latex	10 yrs.	no	yes	OK, but not where there is movement	low	interior only
Silicone	20 yrs.	yes	no	yes, except porous surfaces	high	clear, good for invisible interior application
Butyl Rubber	up to 10 yrs.	no	yes	good, particularly for basement sill plate	low	stringy
Neoprene Rubber	20 yrs.	yes	yes	good, particularly for basement sill plate	medium	good flexibility, hard to apply
Hypalon	20 yrs.	yes	yes	OK	medium	good flexibility, hard to apply, combustible, needs ventilation
Polysulphide	20 yrs.	yes	no	good	high	toxic until cured
One part acrylic terpolymer	20 yrs.	yes	yes	good, do not use with polystyrene	medium	outside only
Polyurethane		yes	yes	good	high	

Rope Caulk — use only as a temporary seal.
Oil-based — generally not recommended, very short life.
Accoustical Caulking — very inexpensive, good quality, good for vapour barrier applications.

CAULKING FACT SHEET

Source: Resource Integration Systems Ltd.

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o AIR SEALING HIGH RISE BUILDINGS
APPLICATION . high rise apartment buildings

Cautions

In buildings with no central mechanical ventilation/exhaust system (i.e. individual fans for exhaust only), thorough air sealing may reduce the infiltration of cold, dry air enough to create high indoor humidity levels.

In buildings with central mechanical ventilation/exhaust systems, adjustments to the system may be necessary in order to supply more fresh air.

Implementation

Air sealing can be done by building personnel, specialized air sealing contractors or caulking/window maintenance contractors.

Discussion

A wide variety of weatherstripping products are available. (See **WEATHERSTRIPPING FACT SHEET** opposite.)

Door sweeps are easiest and least expensive to install. For sliding patio doors refer to **WEATHERSTRIPPING HIGH RISE BUILDINGS**. These doors are similar to common high rise windows.

Spring vinyl weatherstripping is probably the best available product for windows. For aluminum sliding windows with pile seals refer to **WEATHERSTRIPPING HIGH RISE BUILDINGS**.

Savings

Typical savings range from $40.00 to $60.00 per year for a detached house or townhouse. More savings can be expected if existing windows and doors are unusually leaky.

Costs

Materials only: (1982)
- o $4.00 to $10.00 per window
- o $7.00 to $10.00 per door (higher cost if new sweep or threshold)

Contracted services (labour and material): (1982)
- o $25.00 to $30.00 per window
- o $15.00 to $50.00 per door (higher if removal and planing required)
- o $75.00 per sliding patio door

Cautions

Spring loaded vinyl gasket weatherstripping tends to shrink over time leaving gaps at corners, and is therefore not recommended.

Type	Durability	Use	Relative Cost	Degree of Difficulty in Application
1) Aluminum or plastic with (spring loaded) vinyl gasket	good	doors only	high	difficult
2) Spring metal or spring vinyl	good	windows or doors	brass – high-medium vinyl – medium	doors – easy windows – to do sides and top sash the window stop must be removed (adhesive backed is somewhat easier to install but less durable)
3) Tubular gasket	fair	windows and doors	low	fairly easy
4) Foam tapes	poor	windows and doors – good for small trouble spots	low	the easiest
5) Door sweep	good	doors only, just at bottom	low	easy
6) Door threshold	good	base of door frame	medium	difficult

WEATHERSTRIPPING FACT SHEET
Source: Resource Integration Systems Ltd.

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o WEATHERSTRIPPING LOW RISE BUILDINGS
APPLICATION . walk-up apartment buildings, townhouses and detached units

Implementation

Weatherstripping can be done in-house and/or by specialized contractors.

Caulking window and door frames can be done conveniently along with weatherstripping. (See AIR SEALING LOW RISE BUILDINGS.)

Discussion

High rise residential buildings usually have aluminum sash sliding windows that rely on a brush-like pile weatherstrip for sealing against air leakage. This pile can wear out in as little as 5 or 6 years.

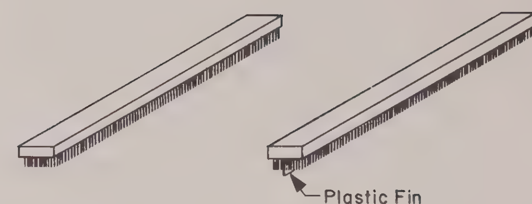
Pile replacement will require the removal of each sash. Slides and collars should be checked and replaced as necessary. Newer types of pile have an internal plastic fin that gives much improved performance and durability, and should be used for all replacement work if possible.

Other repairs to windows can be made conveniently along with replacing weatherstripping. Loose sashes and broken lites can be repaired. Worn or shrinking gaskets can be replaced. Gaps in window frames can be caulked.

Lobby, entrance, garage and penthouse doors should also be weatherstripped. Entrance door weatherstripping is particularly important in tall buildings. The stack effect can create low pressure at the base of the building that draws in huge quantities of outside air.

Savings

In buildings where existing weatherstripping is badly worn, savings will average approximately $16.00 to $30.00 per unit.



PILE WEATHERSTRIP WITH AND WITHOUT PLASTIC FIN

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o WEATHERSTRIPPING HIGH RISE BUILDINGS
APPLICATION . high rise apartment buildings

Costs

Materials only: (1982)

- $2.00 to $4.00 per window
- $7.00 to $20.00 per door

Contracted Services (labour and material): (1982)

- $15.00 to $30.00 per window
- $10.00 to $50.00 per door
- $25.00 per sliding door

Implementation

If the work is to be done in-house, a sample of existing pile weatherstripping should be removed and sent to the window manufacturer, who will supply several samples to be tested for fit, ease of installation and ease of operation.

Weatherstripping work may be contracted to specialized contractors or to manufacturer's field crews.

O.H.C. file EC3004-G "Guidelines for Weatherstripping Apartment Buildings" is an excellent information source.

Discussion

Single glazed windows can be converted to double glazed windows by adding exterior storm windows, adding interior plastic window sheets or installing double glazed replacement windows.

Standard aluminum storm windows are generally suitable only for low rise buildings. In most cases, they will have to be replaced again in about 10 years. High quality storm windows are available for high rise buildings. These may not be applicable to all window types.

Acrylic interior storm window systems are available commercially. Interior systems are easily broken or scratched; successful application will depend on tenant care.

Savings

As a rough guideline, one m^2 of double glazed window area will yield heating fuel savings in the order of \$10.00 per year, provided the heating system is adjusted to suit the reduced heating requirement.

Costs

Approximate costs (1982) are:

- Standard aluminum storm window = \$50.00 per m^2 (including labour)
- Acrylic Interior Storm Window = \$50.00 to \$60.00 per m^2 (not including labour)
- Interior Plastic Film Kit = \$3.50 per m^2 (not including labour)
- Replacement Window = \$350.00 per m^2 (including labour)

NOTES:

SYSTEM	o	BUILDING ENVELOPE
MEASURE	o	DOUBLE GLAZING
APPLICATION	.	all single glazed buildings

Cautions

Interior plastic glazing products may not meet fire safety requirements.

Implementation

Most window products will require installation by the manufacturer or a professional contractor.

Discussion

Prior to insulating an attic, all paths for warm air rising into the attic must be sealed. This includes walls, openings for vents, chimneys, and other penetrations. (See AIR SEALING.) It is essential to provide an air tight air vapour barrier on the warm side (under) of the insulation. The insulating material is then blown-in, poured, or installed in batts. If a small amount of insulation already exists, the air vapour barrier can be placed on top of this insulation. The new insulation is then installed so that at least 2/3 of the total RSI value is **above** the air vapour barrier.

In all cases, it is essential to ventilate the attic cavity above the insulation.

If the attic is used as a living area, the roof can be insulated as a cathedral ceiling. The cavity immediately below the roof can be increased by extending rafters downward. This allows for thicker insulation, and a properly ventilated air space above the insulation.

Savings

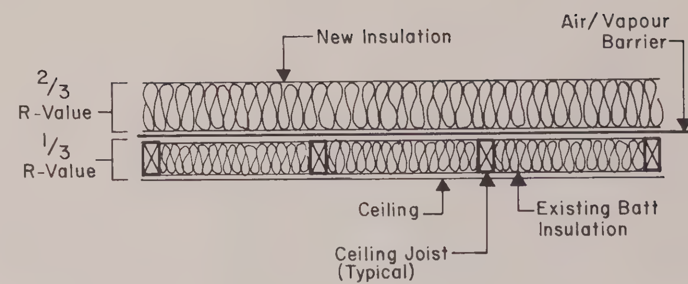
The following general guidelines are based on 1983 energy prices.

Assuming an existing insulation value of RSI 1.0
(e.g. 50mm fiberglass):

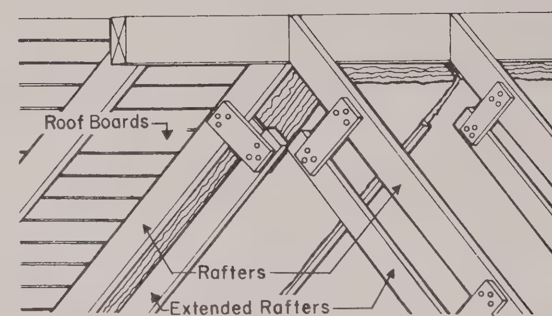
- o savings from adding RSI 2.0 = \$2.25/m^2/yr.
- o savings from adding RSI 3.5 = \$2.65/m^2/yr.

Assuming virtually no insulation (RSI 0.4):

- o savings from addition of RSI 2.0 = \$7.00/m^2/yr.
- o savings from addition of RSI 3.5 = \$7.55/m^2/yr.



ADDITION OF NEW ATTIC INSULATION



INSULATION OF CATHEDRAL CEILING

Source: Ministry of Municipal Affairs and Housing

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o ATTIC INSULATION
APPLICATION . townhouses with accessible attic space

Costs

Average costs (1982) for insulation including air vapour barrier are:

- cost to add RSI 2.0 = \$6.00/m^2/yr.
- cost to add RSI 3.5 = \$7.50/m^2/yr.

Cautions

Proper air vapour barrier and air sealing are important. Moisture from the living area tends to migrate through the ceiling and condense in the cold attic air. This can lead to wet, ineffective insulation, rotting in wooden structures, or freeze/thaw damage in masonry structures.

Discussion

The minimum roof insulation level required by the Ontario Building Code is RSI 3.5.

Any roof that needs replacement can be insulated for a low additional cost. In these cases the existing roof should be removed and all necessary repairs made to the underlying structure (bulk). A vapour barrier should then be installed and covered with insulation (i.e. rigid insulation boards, coated urethane or impregnated paper-covered fibre boards). Foam insulation products should be checked to determine whether they can be used with hot asphalt surfacing.

If the original roof is still in good condition, impermeable foam insulation boards can be placed directly on top of the roof surface. These are covered with a water permeable fabric and gravel for ballast against the wind. This system is known as an "upside down roof".

Savings

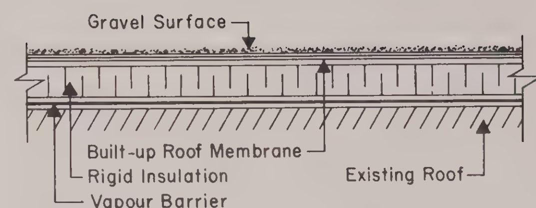
The following general guidelines are based on 1983 energy prices.

Assuming no existing insulation (RSI 0.4):

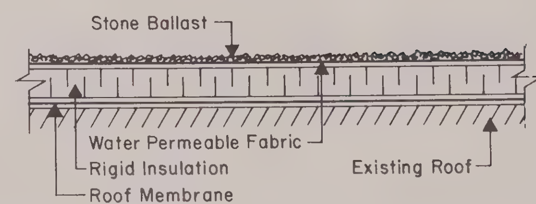
- o savings from addition of RSI 2.0 = $\$7.00/m^2$/yr.
- o savings from addition of RSI 3.5 = $\$7.50/m^2$/yr.

Assuming an existing insulation value of RSI 1.0 (e.g. 50mm fibreglass):

- o savings from addition of RSI 2.0 = $\$2.25/m^2$/yr.
- o savings from addition of RSI 3.5 = $\$2.65/m^2$/yr.



ADDING INSULATION WHEN ROOF NEEDS REPAIR



UPSIDE DOWN ROOF

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o EXTERIOR FLAT ROOF INSULATION
APPLICATION . all flat-roof buildings

Costs

Costs (1982) can be estimated as:

- costs to add RSI 2.0 plus new roof membrane = \$23.50/m^2
- costs to add RSI 3.5 plus new roof membrane = \$32.00/m^2
- costs to add RSI 2.0 only (upside down roof) = \$12.00/m^2
- costs to add RSI 3.5 only (upside down roof) = \$19.00/m^2

Cautions

In both of the above cases, water drainage along sloped roof surfaces to functioning drains is important. Water ponding should be avoided since standing water may penetrate the roof membrane. This can reduce the value of the insulation and cause asphalt bubbling.

If an "upside down" roof is being considered a structural engineer should check loading requirements. The gravel ballast required to keep the insulation in place will be heavier than that required for old roof.

Implementation

Several alternatives should be investigated before deciding on the type and amount of insulation to use. Insulation types vary in cost/RSI-value and availability. Exterior insulation is normally installed by roofing contractors.

Discussion

Roof configurations or mechanical equipment located on the roof may prevent the installation of exterior insulation. In such cases, **interior insulation** may be an attractive solution.

Rigid insulation board can be fastened directly to the ceiling. As an alternative, suspended furring strips can be installed to receive fibreglass batt insulation.

The inside surface below the insulation must be refinished using an air tight vapour barrier and gypsum board.

Savings

The following general guidelines are based on 1983 energy prices.

Assuming no existing insulation (RSI 0.4):

- o savings for adding RSI 2.0 = \$7.00/m^2/yr.
- o savings for adding RSI 3.5 = \$7.55/m^2/yr.

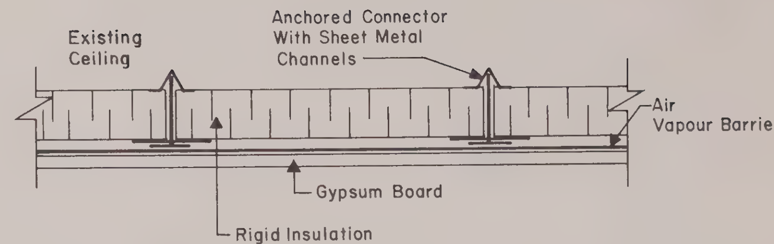
Assuming existing insulation value of RSI 1.0 (e.g. 50mm fibreglass):

- o savings for adding RSI 2.0 = \$2.25
- o savings for adding RSI 3.5 = \$2.65

Costs

Costs for insulating, installing drywall, taping and painting (1982):

- o cost to add RSI 2.0 = \$31.00 - \$35.00/m^2
- o cost to add RSI 3.5 = \$37.00 - \$45.00/m^2



Note: Many diferent commercial systems and on-site fastenings solutions available. (e.g. Z-bars, T-bars, channels, wood strapping, etc.)

INTERIOR FLAT ROOF INSULATION

NOTES:

SYSTEM	o	BUILDING ENVELOPE
MEASURE	o	INTERIOR FLAT ROOF INSULATION
APPLICATION	.	all buildings with no attic cavity

Cautions

A limitation of interior insulation is that it is very difficult or impossible to eliminate thermal bridging and air leakage where partition walls join the ceiling.

Implementation

Interior insulation may be completed by contractors or by in-house personnel.

Interior insulation work in tenanted areas will require a period of vacancy.

Discussion

The preferred location for basement insulation is on the exterior of the basement wall. Opportunity for damage due to frost heave of the soil is eliminated because the wall is kept warm.

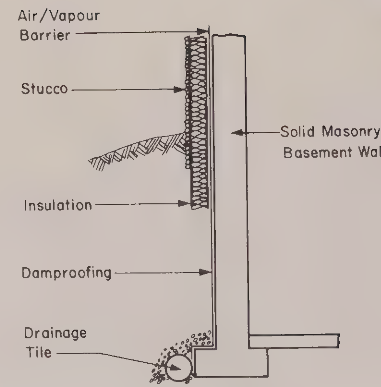
Partial insulation involves the placement of insulation materials such as rigid styrofoam boards on the wall from sill to 600mm (2') below grade. The most significant heat loss is eliminated since losses below the insulation are reduced by the presence of the soil. Excavation of a 2' deep trench around basement walls is necessary for installation.

Full insulation extends from the sill to the footing: excavation to the footing is required. Prior to insulation, the wall should be dampproofed with tar or 6 mil polyethylene. Sheets of insulation (styrofoam or fiberglass board) are place on the wall. Crushed stone is placed on the drainpipe and covered by a filter cloth to keep the system clean of soil.

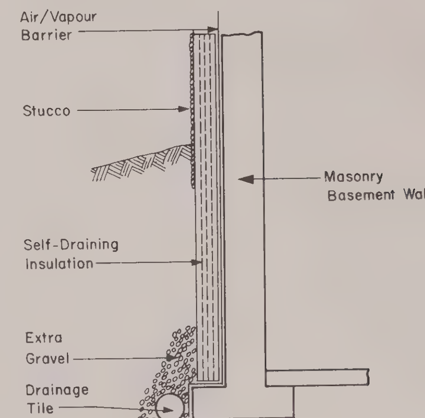
For both options, insulation fastened at the top with masonry fasteners and large washers or flashing. Soil is backfilled, properly compacted and sloped away from the building or drainage. The above grade portion of the insulation is finished with preserved plywood, asbestos board, metal lath and mortar, cement stucco or other material strong enough to take everyday punishment.

Savings

The Basement Insulation Savings Chart (below) provides a tool for estimating potential savings.



PARTIAL EXTERIOR BASEMENT INSULATION



FULL EXTERIOR BASEMENT INSULATION

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o EXTERIOR BASEMENT INSULATION
APPLICATION
- all buildings types
- basement areas within the building envelope

Costs

Partial insulation costs (1983) (including insulation, flashing, parging, excavating, dampproofing, and stone filling) range from $55.00/linear metre (RSI 1.4) to $75.00/linear metre (RSI 2.1) for installation by a contractor. Full insulation costs (1983) range from $55.00/linear metre (RSI 1.4) to $120.00/linear metre (RSI 2.1). Insulation can be very cost effective when performed in conjunction with basement repairs.

Cautions

Drainage pipes should be inspected and replaced as necessary during installation of full insulation.

Implementation

Contractor services and equipment may be required, particularly if major excavation is necessary. Exterior basement insulation is usually installed by a contractor.

Further information is provided in "Re-Insulating Basements," a Home Energy Fact Sheet prepared by the Ministry of Municipal Affairs and Housing.

Retrofit Option		Basement Temperature 18°C (Heated)	13°C (Unheated)
Partial	RSI 1.4	$8.00	$5.60
	RSI 2.1	$8.60	$6.00
Full	RSI 1.4	$10.30	$6.90
	RSI 2.1	$11.00	$7.40

Note: assumes 4000 degree days and $0.035/kWh

BASEMENT INSULATION:
ENERGY SAVINGS
($ per metre of perimeter per year)

Source: Allen Drerup White Ltd.

Discussion

If there are major obstructions to exterior insulation (e.g. driveways, insufficient space between buildings) and if there are no existing moisture problems in the basement, insulation can be installed on the inside of the basement wall.

Interior insulation usually requires a vertical stud wall with insulation batts, or horizontal wood strapping with rigid insulation. There are also commercial systems available that use insulation boards pre-cut for metal or wood strapping. Insulation can extend from the top of the basement wall to 600mm (2') below grade (partial insulation) or to the footing (full insulation).

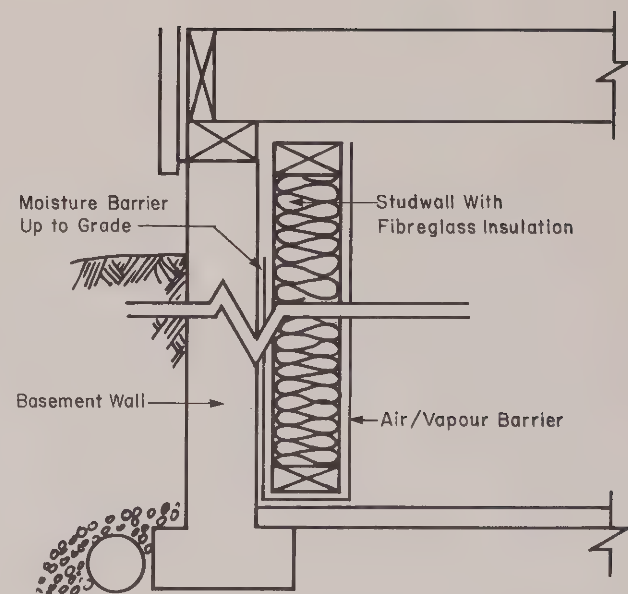
Wood members in contact with a below grade masonry wall should be protected from rot by a moisture barrier up to grade level. An air tight air vapour barrier is required on the warm side of the insulation.

Included in the basement retrofit can be sealing and insulation of joist spaces at the top of the basement wall.

However, in cases where the foundation walls are constructed of clay brick or rubble, the joist spaces should not be insulated. Similarly, joist spaces should be left uninsulated in cases where joists are imbedded in a masonry wall. In all cases, the edge of the sill or joists should be caulked to prevent air leakage.

Savings

The chart shown below provides a tool for estimating potential savings. Sill plate sealing can further increase savings through significant reductions in heat loss through air leakage.



INTERIOR BASEMENT INSULATION

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o INTERIOR BASEMENT INSULATION
APPLICATION
- all building types
- basement areas within the building envelope

Costs

Partial insulation costs in 1982 (including strapping, insulation, vapour barrier and unfinished drywall) range from $26.00/linear metre (RSI 1.4) to $27.00/linear metre (RSI 2.1). Full insulation costs (1982) range from $35.00/linear metre to $36.50/linear metre (RSI 2.1). Insulation can be highly cost effective when performed in conjunction with a basement repair or refinishing.

Cautions

Fire-cut joists supported directly by the masonry wall should be kept warm by not insulating joist spaces on the interior. Cooling of the wall may promote wood rot due to condensation.

Interior insulation reduces warming of the basement wall. Damage could result from frost heave, especially with shallow foundations.

Implementation

Further information is provided in "Re-Insulating Basements," a Home Energy Fact Sheet prepared by the Ministry of Municipal Affairs and Housing.

Retrofit Option		Basement Temperature 18°C (Heated)	13°C (Unheated)
Partial	RSI 1.4	$8.00	$5.60
	RSI 2.1	$8.60	$6.00
Full	RSI 1.4	$10.30	$6.90
	RSI 2.1	$11.00	$7.40

Note: assumes 4000 degree days and $0.035/kWh

BASEMENT INSULATION: ENERGY SAVINGS
($ per metre of perimeter per year)

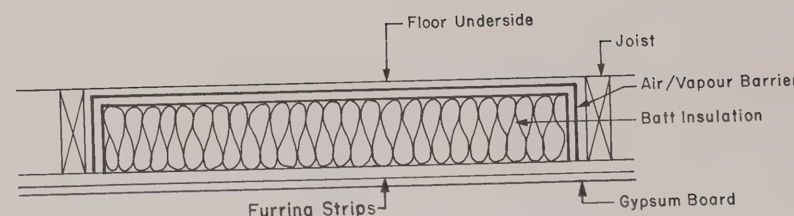
Source: Allen Drerup White Ltd.

Discussion

Heat may be lost unnecessarily from living areas through the floor to an unheated below-grade garage.

Since appearance is generally not a prime consideration in garages, spray insulation can be applied directly to the underside of the floor. Spray products include fire-retardant cellulose and polyurethane foam. Fire regulations will require foams to be covered with acceptable non-combustible materials such as cementitious coatings.

As an alternative for wood frame construction, fibreglass insulation batts can be installed between floor joists on the floor underside. Before installing the insulation, a polyethylene air vapour barrier is fastened directly to the floor underside between the joists. The insulation is then installed and covered with furring strips and gypsum board.



INSULATING FLOOR ABOVE UNHEATED GARAGE
(WOOD FRAME CONSTRUCTION)

Savings

The following general guidelines are base on 1983 prices.

Assuming no existing insulation (RSI 0.4):

- o savings from adding RSI 2.0 = $7.00/m^2/yr.
- o savings from adding RSI 3.5 = $7.55/m^2/yr.

Costs

Costs to apply spray-on insulation, including fireproof layer (1983):

- o costs to add RSI 2.0 = $26.00/m^2
- o costs to add RSI 3.5 = $45.00/m^2

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o INSULATING FLOOR ABOVE UNHEATED GARAGE
APPLICATION . buildings with unheated underground garage areas

Costs to apply batt insulation, including furring and gypsum board (1983):

- costs to add RSI 2.0 = $\$20.50/m^2$
- costs to add RSI 3.5 = $\$22.00/m^2$

Cautions

Sprinkler heads and systems that require access should not be sprayed over.

If winter temperatures in the garage drop below freezing, it should be verified that the sprinkler system is a dry type system (i.e. pipes do not normally contain water). Pipes that may be damaged by freezing should be insulated and/or electrically traced.

Implementation

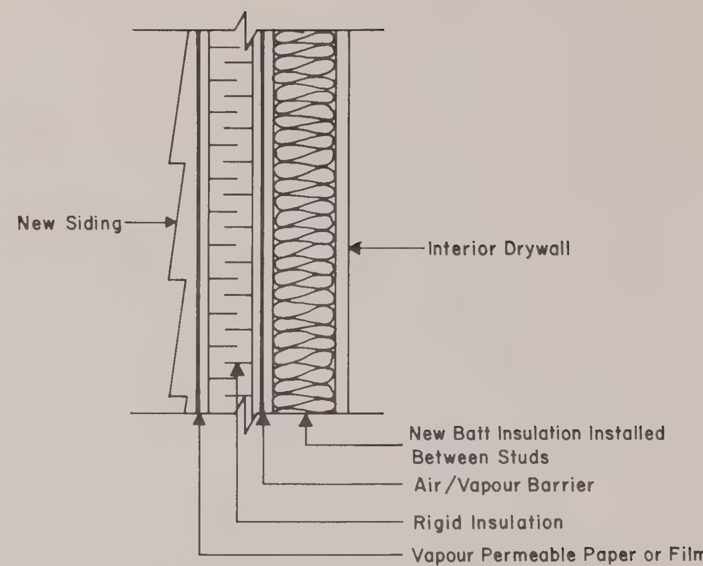
Specialized contractors and equipment will be required for spray-on insulation application.

Discussion

Wood frame construction consists typically of 38mm x 89mm (2" x 4") wood studs spaced at 400mm (16"). The exterior cladding is usually either brick veneer spaced 25mm (1") from the stud wall, or wood or metal siding nailed directly to the stud. Most wood frame buildings constructed in the last decade have RSI 2.1 wall insulation. Buildings constructed before this were insulated to RSI 1.5. Some older buildings have no wall insulation at all.

If new siding is planned for a wood or metal sided wall, polystyrene or fiberglass rigid insulation boards can be installed. After removal of the old siding, batt insulation can be placed between studs. The building is then wrapped in an air tight air vapour barrier. The rigid insulation is then applied on top of the air vapour barrier. The exterior rigid insulation must have 2/3 of the total RSI-value of the wall insulation. A air/water permeable paper or film should cover the insulation to guard against rain penetration. The new siding is then fastened by nailing through the insulation into the studs, or by attaching wood strapping as nailing strips.

As an alternative when existing siding cannot be removed, rigid insulation boards can be fastened on top of the existing siding and covered with the new siding.



ADDITION OF WALL INSULATION WITH NEW SIDING

Savings

The following general guidelines are based on 1983 energy prices.

Assuming no existing insulation (RSI 0.4):

- o savings from adding 115mm insulation (RSI 2.7) (stud and brick veneer cavity) = $5.70/m^2/yr.

NOTES:

SYSTEM o BUILDING ENVELOPE
MEASURE o WALL INSULATION
APPLICATION . townhouses
. wood frame construction

- savings from batt insulation plus exterior rigid insulation (RSI 3.7) = \$5.90/m^2/yr.

Assuming existing insulation of RSI 1.5:

- savings from adding exterior insulation boards (RSI 2.5) = \$1.40/m^2/yr.

Costs

General cost guidelines (1982) are:

- cost of external insulation option (including batt insulation, air vapour barrier, rigid insulation and sheathing paper/film) = \$9.00/m^2
- cost of new exterior cladding = \$11.00/m^2

Cautions

Some form of air vapour barrier must be installed to guard against condensation in the wall cavity.

Implementation

It is usually advisable to contact an experienced contractor for wall insulation work.

LIGHTING SYSTEMS

In most multi-unit buildings, lighting is not a major energy use. A large portion of the lighting energy load is from tenant living areas. Common area lighting typically represents less than 5% of total building energy use.

Lighting energy use is the product of lighting load and hours of use. For example, a 100 watt light bulb operated for 8 hours per day for one year will consume:

8 hours/day x 365 days/yr. x 100 watts
= 292,000 watt-hours
= 292 Kilowatt-hours (kWh)

The operating cost for the light will depend on the utility rate schedule for the building. Assuming the average cost of a kWh of electricity is $0.04, the cost of energy becomes:

292 kWh x $0.04/kWh
= $11.68/yr.

Energy conservation measures for lighting fall into one of two categories: reducing lighting energy load or reducing hours of operation. An example of a lighting energy load measure could be changing a 100 watt bulb to a 60 watt bulb (a 40% saving). An example of an hours of operation measure would be installing a timer switch to reduce hours of operation from 8 hours/day to 6 hours/day (a 25% saving).

Energy Conservation Measures for lighting require some knowledge about acceptable **light level** and types of **light source.**

- **Light Levels**

  The amount of light emmitted by a light source is measured in **lumens.** The light in a room is measured in **lux,** which is simply a measure of lumens per unit area of illuminated space. The light level in a room will depend on the amount of lumens from light fixtures plus lumens from daylight through windows. Recommended light levels depend on the specific use in a given area. Building storage space, for example, will require a lower light level than bathroom and kitchen areas. Figure L-1 (opposite) shows light level requirements for various public uses in a building.

Figure L-1: RECOMMENDED LIGHTING LEVELS FOR PUBLIC SPACES

Space	Level (lux) and where measured	
Assembly Spaces[b]	150	1.2m above floor level
Entrance halls corridors[c,d]	150	1.2m above floor
Stairways[d]	100	on stair tread
Storage rooms, garbage rooms[b]	50	on floor
Laundry rooms and washrooms[b]	200	on 1.2m above floor
Equipment rooms[b]	50	on floor
Garages	50	on floor
Swimming pools[b]	300	at water level
Exercise rooms[b]	150	1.2m above floor

a Check that levels specified comply with local codes.
b Turn off lighting when spaces not in use.
c Lighting may be reduced by 50 per cent at night-time.
d In senior citizens' residences, lighting levels should be increased by 50 to 100 per cent over recommended levels.

CAUTION should be exercised when reducing lighting in corridors and staircases.

o Light Sources

Artificial lighting is provided by some form of lamp. Typical lamps in existing buildings are the 60 watt incandescent light bulb and the 40 watt fluorescent tube. Figure L-2 shows characteristics of various lamps.

Figure L-2: CHARACTERISTICS OF LAMP TYPES

	Lighting Output Lumens	Life in Operating Hours	Cost per Lamp*
40 watt incandescent	450	1000	$1.28
40 watt incandescent long-life	420	1000	$2.48
40 watt fluorescent standard	3,150	20,000	$2.34
400 watt mercury	22,500	24,000	$33.00
400 watt metal halide	34,000	15,000	$96.98
400 watt high pressure sodium	50,000	24,000	$117.56

* Suggested list price (1982)

The fluorescent lamp is much more efficient than the equivalent incandescent lamp. The expected life of a fluorescent lamp also exceeds that of an incandescent bulb.

Fluorescent, mercury, metal halide and high pressure sodium lamps require a **ballast** to provide light output. A ballast acts like a transformer by raising voltage to power the lamp. Although a ballast does not produce light, it consumes energy while energized.

The relative energy efficiency of various lamps including their ballast loss is shown in Figure L-3. The term **efficacy** refers to light output (lumens) for power input (watts), and is a measure of lamp efficiency.

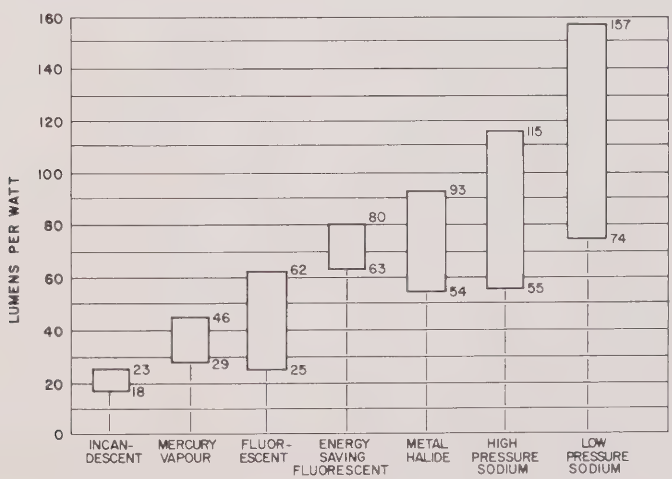


Fig. L-3
LAMP EFFICACY INCLUDING BALLAST LOSS

Discussion

All types of lamps can be removed in order to reduce lighting energy load. However, incandescent and fluorescent lamps are most often suitable for removal. Lamps can be removed whenever a building space is overlit as compared to the recommended light levels in Figure L-1. Common techniques are to remove incandescent bulbs in a 2-bulb fixture or to remove fluorescent lamps and disconnect the ballast. (If ballast is left connected it will still consume energy.)

Savings

Annual savings =

load reduction (kW) x annual operating hrs. x energy costs/kWh

Costs

Labour costs are usually the major cost for lamp removal.

Cautions

It is important to establish present lighting levels and power loading, and to decide on new target lighting levels.

Care must be exercised in selecting lamps for removal in order to avoid unnecessary ballast consumption, ballast failure, lamp failure and power factor penalties.

Removal of lamps that provide task lighting will likely generate tenant complaints. Removal of lamps that illuminate large vertical surfaces can transform a "bright" environment into one that is dull or gloomy.

Savings Example: **LAMP REMOVAL**

Assume removal of one 2-tube fluorescent light fixture:

40 watt tube
40 watt tube
16 watt ballast

96 watt lighting load reduction

Hours of operation	= 24 hrs./day x 365 days/yr.
Electricity Cost	= $0.04/kWh
Annual Savings	= 96 watts x 8760 hrs/yr x $0.04/kWh
	$33.64 per year

(Note: 96 watts = .096 kw)

NOTES:

SYSTEM	o LIGHTING
MEASURE	o LAMP REMOVAL
APPLICATION	. all building types
	. all lighting types

Implementation

In most cases, existing personnel can remove incandescent bulbs. Fluorescent bulb removal may require the assistance of an electrician if ballasts must be disconnected.

Discussion

Fluorescent lamps, depending on wattage, are up to 4 times more efficient than incandescent lamps, and therefore require as little as 1/4 the input wattage to achieve the same light level. In addition, fluorescent lamps last up to 20 times longer than incandescent lamps.

Fluorescent lamps are available in lengths from 0.15m (0.5 ft.) to 2.4m (8 ft.) and in wattages from 40W to 220W. Shapes range from linear to circular. In general, linear lamps are the least expensive. Conversion kits are available to screw a circular fluorescent fixture into an incandescent lamp socket. Recent product developments indicate that manufacturers are achieving more compact shapes for fluorescent lamps.

Savings

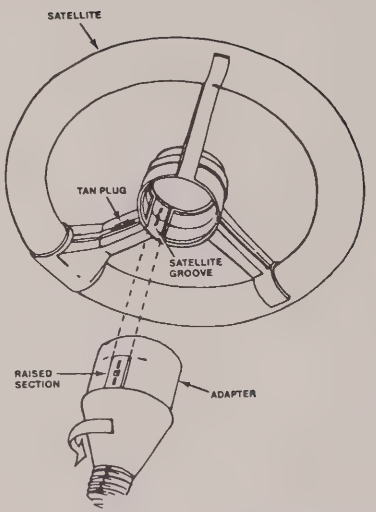
The chart opposite shows a comparison of incandescent and fluorescent lamps.

Annual savings =

load reduction(kW) x annual operating hrs.(hrs/yr)
x energy costs ($/kWh)

Costs

Costs of conversion kits range from $10.00 to $50.00 (1983). In general, the kit must cost less than $33.00 to obtain a simple payback of 5 years.



CONVERSION KIT FOR CHANGING FROM INCANDESCENT TO FLUORESCENT LAMP

NOTES:

SYSTEM o LIGHTING
MEASURE o CONVERSION TO FLUORESCENT LAMPS
APPLICATION
- all existing building types
- existing incandescent lamps

Cautions

Installation of circular fluorescent kits is not recommended in high traffic areas such as apartment corridors. Theft of the lamps can be a major problem.

Implementation

Installation of new fluorescent fixtures may require the assistance of a qualified electrician. Replacement of incandescent bulbs with the screw in type is a do-it-yourself measure.

CONVERSION: INCANDESCENT TO FLUORESCENT LAMPS

Incandescent		Compact or Circular Fluorescent		Watts Saved
Wattage	Initial Lumens	Wattage (including ballast)	Initial Lumens	
60	870	22	870	38
		18	1100	57
75	1190	22	1000	53
		27	1000	48
100	1750	44	1750	56

Discussion

Existing fluorescent lamps can be replaced by energy saving lamps that require lower wattage and produce less light.

Two classes of lower wattage replacement lamps are available; those giving wattage reductions of up to 20% and those giving wattage reductions of 30-65%.

There are three generic lamp types that accomplish wattage reductions of greater than 30%:

- capacitative lamp giving no light output
- resistive lamp giving no light output
- capacitative lamp giving light output

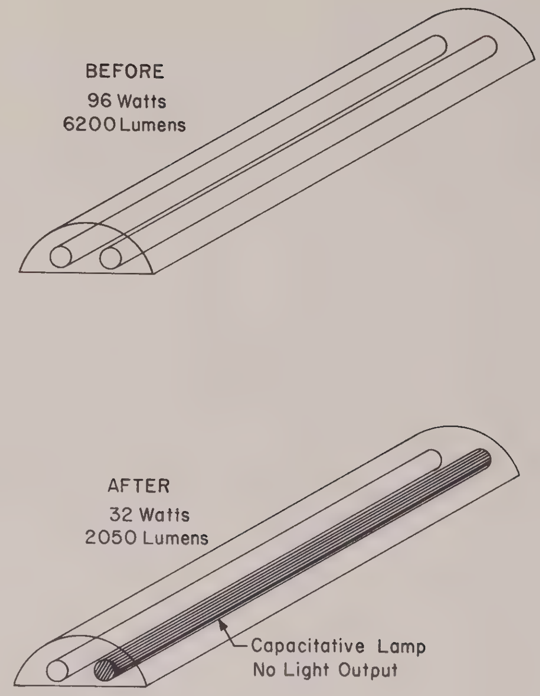
Each type can replace a regular fluorescent lamp with certain ballasts in two fixtures. Capacitative lamps normally extend the life of remaining lamps and the existing ballast. Resistive lamps can shorten lamp and ballast life and result in poor power factor characteristics.

Savings

Annual savings =
load reduction (kW) x annual operating hrs (hrs/yr)
x energy costs ($/kWh)

Costs

Low wattage lamps typically cost up to $15.00 each (1983).



CONVERSION TO LOWER WATTAGE FLUORESCENT LAMPS

NOTES:

SYSTEM o LIGHTING
MEASURE o CONVERSION TO LOWER WATTAGE FLUORESCENT LAMPS
APPLICATION . all building types
. existing fluorescent lighting

Cautions

This measure should be adopted when space is overlit and fixture removal is not practical or desirable.

Implementation

This is normally a do-it-yourself measure.

Discussion

In general, **energy saving fluorescent lamps** have an improved lamp efficacy compared to standard lamps. The table opposite shows the relative lamp efficacies of standard and energy efficient fluorescent lamps.

Installing energy efficient lamps can produce more light that standard lamps for the same wattage. This will enable fewer fixtures to be used. Energy is conserved only when power loading is reduced by reducing the number of fixtures.

Savings

Annual savings =

load reduction (kW) x annual operating hrs.(hrs/yr)
x energy costs ($/kWh)

Costs

Energy efficient fluorescent lamps typically cost from $0.30 to $1.00 more per lamp than standard fluorescent lamps.

Cautions

Conversion to high lumen output fluorescent tubes without replacing old ballasts may result in an acceleration of ballast failure.

Implementation

Lamp replacement can be done by existing personnel. The assistance of an electrician may be required to replace old ballasts.

FLUORESCENT LAMP EFFICACY

LAMP	EFFICACY (lumen/watt)
Standard Cool White	74 - 84
Energy Saver Cool White	76 - 93
Energy Saver Lite White	87 - 100

Note: 40 input watts
4' length
3,150 initial lumens

The range of efficacies is due to the various specific model types available.

NOTES:

SYSTEM o LIGHTING
MEASURE o CONVERSIONS TO HIGHER EFFICIENCY FLUORESCENT LAMPS
APPLICATION
- all building types
- existing fluorescent lighting

APPLIANCES

Average appliance energy consumption and demand levels are shown in Figure A-1.

Appliance	Energy Consumption kWh per Month	Demand per Unit (Watts)
Refrigerator	150	200
Freezer	75	100
Range	65	400
Clothes Washer	125[1]	—[2]
Clothes Dryer	85	400
Dishwasher	155[1]	—[2]

Notes: 1 - Includes Hot Water Energy
2 - Can Be Kept Low Through Water Heater Controls

Fig. A-1
APPLIANCE ENERGY CONSUMPTION/DEMAND

Reductions of up to 50% of the energy used by appliances have been demonstrated. However, in general there is little that can be done to most appliances to improve energy efficiency after they have been purchased. It is, therefore, important to consider energy performance whenever purchasing new appliances. The Energuide program for labelling new appliances according to average energy consumption level is designed to assist in making wise selections.

Energy consumption depends largely on how the appliances are used on a daily basis. This, in turn, depends on the tenants, who can be informed and encouraged to use appliances efficiently.

Summarized below are **measures** for reducing the consumption of **existing appliances** and **guidelines** to assist in the purchase of **new appliances**.

ENERGY CONSERVATION MEASURES FOR EXISTING APPLIANCES

Laundry

The "average" family washes 34 loads of laundry per month. Small savings per load become significant savings per year, particularly in multi-family laundries.

Washer

- Ninety-five percent of the energy required to operate clotheswashers is used to heat water. This can be reduced by 30% if cold water is used for the rinse cycle. The quality of the wash will not be affected.
- Warm water settings use hot and cold water in roughly equal proportions and can therefore cut hot water consumption in half related to hot water settings. Again, the quality of the wash will not be affected.
- A better spin cycle will reduce moisture left in clothes, thereby saving on dryer energy consumption.
- In buildings with central water heating systems, it is better to raise the temperature at the laundry, rather than to provide the whole system with hotter water.

Dryer

- The energy required to remove each unit of water rises dramatically when the moisture content drops below 30% of bone dry weight. (Acceptable dry is defined as 2 1/2 - 5% moisture content.) Automatic-controls can reduce overdrying, by taking the guesswork out of a timed cycle. Retrofit, however, may be a problem; some machines will not adapt and tenants may not feel they are "getting their money's worth" from a coin-operated machine.

Other Appliances

Refrigerator

- refrigerator door seals should be adjusted to ensure a proper seal when the door is shut
- the refrigerator should be levelled so that the automatic door closing mechanism operates properly
- condenser coils should be kept clean
- the refrigerator should be located away from heat sources such as ranges, dishwashers, heating vents, etc.
- the back of the refrigerator should be at least 2 inches from the wall to ensure that air circulates freely around the condensor coil
- disconnecting anti-sweat heaters (i.e. heaters that keep the outside surface warm to touch) can save up to 20%.
- disconnecting the butter keeper heater can save 2%.

Range	o	door seals should be checked
	o	elements warp with age and become less efficient. Old elements can be replaced.
Dishwasher	o	disabling the heater element for drying can save about 10% of the electrical energy required.
Room Air-Conditioner	o	air conditioners should be removed or at least covered in winter
	o	the use of timers should be encouraged so that air conditioners are not operating longer than necessary and, if possible, not during periods of peak electrical demand.

NEW APPLIANCE PURCHASING GUIDELINES

Washer	o	front loading clotheswashers use 30-40% less water than top loading machines.
Dryer	o	electric dryers can contribute to electrical demand if operated during peak demand periods. This can be very expensive, depending on local utility rate structures. Natural gas dryers should be purchased if possible.
Refrigerator	o	testing has shown that some currently available refrigerator models consume approximately one half the energy consumed by other of similar size and style. Energuide ratings should be compared carefully.
	o	frost-free refrigerators generally are less energy-efficient than normal defrost refrigerators.
Range	o	forced convection ovens use 20% less energy than regular ovens
	o	self-cleaning ovens are more energy-efficient than regular ovens
	o	standard surface elements are 60-80% efficient; smooth top elements are 50-60% efficient.

Proper maintenance of all building systems is essential for energy efficient operation. Energy waste is often the result of poorly maintained or faulty equipment. Heat energy, for example, can be lost through leaks in pipes and ducts or poorly sealed valves and dampers. Building systems should be thoroughly inspected and equipment should be cleaned, lubricated and repaired or replaced as necessary when implementing conservation measures.

Proper maintenence has significant benefits in addition to energy efficient operations. Maintenance improves equipment performance and reliability, increases equipment life, and adds predictability to budgeting for building operations. Increased tenant satisfaction will result from less frequent equipment breakdowns.

A planned preventative maintenance program should be initiated effectively along with an energy management program. Preventative maintenance begins with a detailed inspection of all equipment. This should be done in conjunction with an energy audit and analysis. Maintenance instructions and schedules are then prepared for each specific item of equipment. Regular inspections are then carried out by building personnel. These inspections will include checks on furnace/boiler combustion efficiency, insulation, temperature control settings and other energy-related items. Cleaning, lubrication, adjustments and repairs are performed as necessary to ensure equipment problems are solved before they become serious.

Each building will have specific maintenance requirements. Many of these will be detailed in operations manuals provided by the manufacturers. Other references, listed in Section 8 of this Manual, provide detailed maintenance information. In addition, a general checklist of maintenance requirements follows.

MAINTENANCE CHECKLIST

General

- o Keep all equipment clean, removing dirt, dust, scale, rust, and any contaminants as they accumulate.
- o Schedule a thorough cleaning of all equipment once a year.
- o Have water treated to remove contaminants.
- o Check, clean and replace filters to maintain efficiency.
- o Inspect all fan belts, electrical contacts, brushes in electrical motors, diaphragms on control valves and damper mechanisms.
- o Check that bolts and electrical connections are tight.
- o Inspect duct and pipework insulation to ensure that it is not damaged or wet.
- o Check for deterioration of electrical insulation.
- o Check gaskets to ensure that they are in good condition.
- o Repaint rusted or damaged equipment.

Building Envelope

- o Replace worn or broken weatherstripping.
- o Rehang misaligned doors and window frames.
- o Replace worn or missing gaskets on garage or overhead doors.
- o Caulk exterior building joints.

Heating Equipment

- o Check the air-to-fuel ratio to ensure efficient combustion.
- o Check boiler stack temperature.
- o Check flues and chimneys for blockages or improper draft conditions.
- o Clean all heat-transfer surfaces annually.
- o Clean boiler equipment periodically, including gas burners, fuel filters, ignition electrodes, nozzles, burner fan blades, burner flame stabilizers, and air cone/flame-retention head.

- Check all gaskets, adjusting screws, locknuts, sheave set screws and valve packings regularly.
- Check for cracks in the boiler refractory lining and repair as necessary.
- Inspect the boiler insulation to ensure that it is not damaged.
- Repair all leaks in water, steam, gas and flue-gas systems.
- Check burner firing period.
- Inspect oil-line strainers. Clean or replace if dirty.
- Make regular operating checks according to manufacturer's recommendations.
- Open boiler relief valve to ensure that it is functioning.
- Log boiler temperature.
- Log boiler pressure.
- Check all steam traps regularly.

Cooling Equipment

- Check oil level and pressure in compressors each week.
- Check the refrigerant moisture - liquid indicator each week.
- Check discharge pressure and temperature, condenser and chilled-water temperature and flow rates regularly.
- Check oil filter and refrigerant dryer regularly and change as required.
- Test oil in sump for acidity periodically.
- Lubricate fan and motor bearings and check gear-box lubricants on evaporative condensers each month.
- Drain the condensing water circuit on water-cooled condensers and check tubes and waterbox annually.
- Clean condenser tubes annually.
- Have all controls recalibrated annually.
- Test refrigerant for contaminents annually.
- Perform vibration test on compressor motor to check for shaft or impeller imbalance or bearing wear.
- Use megohm tests to check deterioration of compressor-motor winding insulation.

- o Bleed water from cooling towers to remove impurities.
- o Treat water chemically if bleeding cannot control scaling and corrosion.
- o Check water-distribution and reservoir system regularly.
- o Check for leaks in chilled-water and condenser-cooling systems, (ducts, air-handling equipment and dampers), chemical-feed and oil systems.

Hot Water Systems

- o Check for leaks in hot-water systems: inspect equipment connections, expansion joints, pumps and valves.
- o Inspect plumbing systems in public and service areas, particularly hot-water controls regularly.

Valves

- o Check for leaks and ensure packing is tight.
- o Verify operation of manual valves by opening and closing them periodically.
- o Keep exposed valve stems and threads clean and lubricated.
- o Inspect control valves visually by opening them up once a year.
- o Verify control sequence of control valves once or twice a year.

Pumps

- o Lubricate motor and pump bearings every three months, or as recommended by the manufacturer. At least every three months, check condition of belts.
- o Check alignment of direct-driven pumps.
- o Inspect wet-packed seals monthly and adjust as required.
- o Inspect mechanical seals for leaks every one to three months.
- o Check all nuts and bolts for tightness and bearings for wear.
- o Remove all dirt and gummy material periodically from valves and valve seats of reciprocating pumps every six months, drain and refill the crankcase. Inspect pistons and cylinder liners for signs of wear.

Fans

- Check lubrications of fan and motor bearings every three months, or according to manufacturer's recommendations.
- Check all belts for alignment, tension and signs of wear.
- Check fan for signs of vibration.

Motors

- Check lubrication every one to three months.
- Inspect brushes and brush gear.
- Clean inside motor periodically by vacuum or blowing.
- Check bearings for signs of wear.
- Check condition of driven equipment and motor-control gear.
- Check hold-down bolts for tightness.
- Rotate shafts of motors not in use.

Electrical Installations

- Inspect for damage and overheating of cords, cables and switches.
- Check contacts in switchgear and motor-control gear for pitting.
- Check condition of gaskets for equipment installed in damp or dirty environments.
- Check for water leaks in equipment installed out of doors.
- Check for oil leaks from oil-filled equipment.
- Lubricate switch and contact mechanisms according to manufacturer's recommendations.
- Check operation of switches and interlocks.
- Check tightness of terminal connections.

Lighting

- Clean light fixtures at least once a year.
- Replace flickering florescent tubes to avoid premature ballast failure.

Source: adapted from CMHC

Tenants are the primary "users" of energy in multi-unit residential buildings. They have an obvious and important role in energy conservation initiatives. This role should be considered carefully before implementing conservation measures. The degree of success of many measures will be highly dependent upon acceptance by the tenants.

THE TENANT PROFILE

Basic characteristics of the tenant group should be included as part of the information required to implement an energy management program for a particular building.

Different tenant groups have different energy use habits and schedules. Careful consideration of these factors will enhance the effectiveness of conservation measures, and help to avoid adverse tenant reactions. Some examples illustrate:

- **the type of tenant group affects the timing of peak energy demands.** For example, senior citizens tend to use energy moderately throughout the day with slight morning and evening peaks. They use very little energy at night. Other tenant groups will have different energy use patterns based on common working schedules.

- **the type of tenant group affects temperature level requirements.** Senior citizens, again as an example, require generally higher space temperatures in winter than other tenant groups.

- **the type of tenant group affects overall energy consumption levels.** Families with children, for example, typically have higher demands for hot water and appliance energy use. As a result, there is usually a greater potential for savings in these areas.

METERING

The type of metering system in a building determines whether the owner, the tenant, or both, pay directly for energy. This, in turn, establishes who has a direct financial incentive to conserve. Since financial benefit is the most powerful incentive, metering systems and their implications should be carefully considered.

Bulk metering refers to a master meter that measures consumption for all or a large group of units and/or common areas. The owner pays the utility. Individual metering refers to separate meters for each unit. Each tenant pays the utility.

Typical metering combinations are:

- o all electricity and fuels bulk metered.
- o individually metered electricity for lights and appliances; bulk metered fuels for space and water heating; bulk metered electricity for common lighting and services.
- o individually metered electricity for heat, lighting and appliances; bulk metered fuels for water heating and make-up air heating; bulk metered electricity for common lighting and services.
- o individually metered electricity for heating, lighting, appliances, cooling and individual hot water tanks; bulk metered fuels for make-up air heating; bulk metered electricity for common lighting and services.
- o individually metered electricity for lights and appliances; individually metered gas for water and space heating, bulk metered electricity for site services only.

Individual metering may tend to attract energy-conscious tenants to the building. Tenants have a direct financial incentive to conserve. This is likely to encourage tenants to practice energy conscious lifestyle habits and apply no cost measures such as temperature set-backs, closed windows, carefully used lights and appliances, etc.

It is unlikely that tenants will implement higher cost measures such as insulation. Anticipated tenures are usually shorter than anticipated payback periods. Furthermore, individual metering provides little incentive for owners to implement energy conservation measures, particularly those that require considerable capital investments.

It is noteworthy that individual metering usually results in tenants paying a premium for energy that is priced according to a **declining block structure** (see Reading Energy Bills). They will not consume individually the quantities of energy required for rate categories with lower unit energy prices.

Also, individual metering in apartment buildings can sometimes lead to an unfair allocation of energy costs. For example, units with a low temperature setting will benefit from heat transfer through walls from adjacent units. Corner units will require more heating energy than interior units. Vacant units will be heated by adjacent occupied units.

In bulk metered buildings, tenants have little or no financial incentive to conserve. They are not directly aware or accountable for energy expenditures. Though energy costs are eventually included in rents, most tenants do not see their contribution to conservation as significant for the whole building.

Bulk metering encourages the building owner to operate building systems as efficiently as possible. In some cases, even energy conservation measures with higher capital requirements may be economically justified.

TENANT INVOLVEMENT IN ENERGY CONSERVATION

In bulk metered buildings where tenants do not have a direct financial incentive to conserve energy, the property manager may have difficulty implementing measures such as temperature setbacks or the installation of water saving shower heads. Tenants may reject such measures as uncomfortable or inconvenient.

Some managers attempt to "pre-sell" the implementation of certain conservation measures through printed notices and/or personal visits to tenants. Measures and their justification are explained to tenants with the intent of gathering support and acceptance before measures are implemented.

Other managers implement energy conservation measures without consulting tenants beforehand. Tenant feedback may provide an indicator of dissatisfaction (e.g. temperatures are too low). From this, the manager is able to determine levels of tenant acceptance.

It is important to recognize, however, that many energy conservation measures have a positive impact on tenant comfort. Examples are caulking, weatherstripping and double glazing, all of which reduce drafts and cold spots in apartment units. Furthermore, comfort, as well as financial benefit, is a very important factor in motivating individuals to accept or implement energy conservation measures.

Given the importance of comfort as a motivational factor, some property managers may reduce energy costs by encouraging and assisting tenants in caulking, weatherstripping, installing interior storm windows, etc. as part of the regular redecorating work that usually takes place when an apartment unit changes hands.

To date, several techniques have been used to motivate tenants to conserve energy.

- signs can be placed in strategic locations to encourage tenants to turn lights off, close windows, set back thermostats, etc.

- notices, pamphlets, personal visits and tenant meetings have been used as vehicles for educating tenants as to the benefits of energy conservation.

- regular feedback as a motivational tool has not yet been attempted extensively, but has potential. Applications could include, for example, visible meters in foyers or hallways, or regular notices describing consumption trends and costs. The intention is to inform and educate tenants on a regular basis as to continually rising energy costs and the impact of conservation measures.

- formulas have been developed for dividing bulk energy bills among the tenants in a given building without converting to individual meters. Tenants then become aware of monthly energy costs and, if a large number of tenants conserve energy, these monthly costs may be reduced.

ENERGY CONSERVATION MEASURES FOR TENANTS

Heating

- Lower winter thermostat settings.
- Turn back thermostat when leaving the apartment unit for extended periods.
- Do not turn thermostat up and down frequently during the day. The heating system will probably consume more energy.
- Remember that every degree helps. Even moderate temperature setbacks contribute to reduced energy costs.
- Report drafts or cracks around doors and windows.
- Open curtains on bright sunny days. Close them at night to help reduce heat loss.
- Do not block heating registers with furniture, curtains, etc.
- Close windows and doors to keep heat in.
- Keep heat generating appliances away from thermostats.

Air-Conditioners

- Set thermostat at highest comfortable temperature
- Open windows instead of operating the air conditioner when outside temperatures drop.
- Run room air conditioners only on hot days and set fan speed at high. In very humid weather, position the fan at a low speed to remove more moisture.
- Turn off the air conditioner when away from the apartment.
- Minimize the use of appliances that generate heat. Cook during cooler parts of the day.
- Turn off lights not in use.
- Use an exhaust fan to reduce heat when cooking in the kitchen, and in the bathroom, use a fan when showering.
- Keep drapes and blinds closed during the day.
- Keep doors and windows closed when the air conditioner is operating.
- Do not block the air conditioner with furniture or drapes.

Hot Water

- Report leaky faucets or pipes.
- Take a shower instead of a bath.
- Consider a water-saver shower head.
- Check daily habits. Plug the sink when washing, shaving or washing dishes.
- Wash only full laundry loads.
- Remember that you do not need to use hot water for every kind of wash.

Lighting

- Turn off lights in unused areas.
- Substitute lower wattage lamps when strong light isn't needed.
- Use one large bulb instead of several small bulbs for higher illumination and efficiency
- Use task lighting.

Appliances

- Cook several items in the oven at once.
- Turn off the oven or range a short time before cooking is finished.
- Thaw frozen foods before cooking.
- Match the diameter of pots and pans with the elements to be used.
- Use lids on pots.
- Cook with glass or ceramic baking dishes in the oven.
- Use small, counter-top appliances instead of the range whenever possible.
- Maintain the freezer temperature at no more than -18°C.
- Do not overload the regrigerator and freezer sections.
- Clean the condenser coils at the back or bottom of refrigerator.
- Do not leave refrigerator door open for long periods of time.
- Check the refrigerator door gasket seal.

METRIC CONVERSION FACTORS

LINEAR MEASURE

1 inch (in)	x	25.4	=	millimetres (mm)
1 foot	x	0.305	=	metre (m)
1 mile	x	1.609	=	kilometres (km)
1 millimetre (mm)	x	0.039	=	inch (in)
1 metre (m)	x	3.28	=	feet (ft)
1 kilometre (km)	x	0.62	=	mile (mi)

SQUARE MEASURES

1 square foot (ft^2)	x	0.093	=	square metre (m^2)
1 square metre (m^2)	x	10.76	=	square feet (ft^2)

CUBIC MEASURE

1 cubic foot (ft^3)	x	0.028	=	cubic metre (m^3)
1 cubic metre (m^3)	x	35.315	=	cubic feet (ft^3)

LIQUID MEASURE

1 gallon (gal)	x	4.55	=	litres (l)
1 US gallon (US gal)	x	3.78	=	litres (l)
1 litre (l)	x	0.22	=	gallon (gal)

MASS AND DENSITY

1 pound (lb)	x	0.45	=	kilogram (kg)
1 kilogram (kg)	x	2.2	=	pounds (lb)

TEMPERATURE

1 degree F - 32	x	0.555	=	degree C (C)
1 degree C x 1.8 + 32			=	degree F (F)

VELOCITY AND RATE OF FLOW

1 foot per minute (ft/min)	x	0.005	=	metre per second (m/s)
1 cubic foot per minute (ft^3/min)	x	0.000472	=	cubic metre per second (m^3/s)
1 gallon per minute (gal/min)	x	0.076	=	litres per second (l/s)
1 metre per second (m/s)	x	3.28	=	feet per second (ft/sec)
1 cubic metre per second (m^3/s)	x	2118.88	=	feet per minute (ft^3/min)
1 litre per second	x	13.2	=	gallons per minute (gal/min)

ENERGY UNITS

1 British Thermal Unit (Btu)	x	0.001055	=	megajoules (MJ)
1 megajoule (MJ)	x	947.8	=	British Thermal Units (Btu)
1 Kilowatt hour (kWh)	x	3.6	=	megajoules (MJ)
1 megajoule (MJ)	x	0.2777	=	Kilowatt hours (kWh)
1 Kilowatt hour (kWh)	x	3412	=	British Thermal Unit
1 British Thermal Unit	x	0.00029	=	Kilowatt hours (kWh)

EQUIVALENT ENERGY VALUE OF FUELS

Electricity	=	3.6	MJ/kWh			
Natural Gas	=	37	MJ/m^3	=	10.3	kWh/m^3
	=	1,048	MJ/Mcf	=	291	kWh/Mcf
Oil #1	=	36	MJ/l	=	10	kWh/l
	=	163.8	MJ/gal	=	45.5	kWh/gal
Oil #2	=	38	MJ/l	=	10.6	kWh/l
	=	163.8	MJ/gal	=	48.0	kWh/gal
Oil #4	=	40	MJ/l	=	11.1	kWh/l
	=	182	MJ/gal	=	50.5	kWh/gal
Oil #6	=	42	MJ/l	=	11.7	kWh/l
	=	191	MJ/gal	=	53.2	kWh/gal
Coal	=	21	MJ/Kg	=	5.8	kWh/Kg
	=	9.5	MJ/lb	=	2.6	kWh/lb
Steam	=	23	MJ/Kg	=	6.4	kWh/Kg
	=	10.3	MJ/lb	=	2.9	kWh/lb
Propane	=	26	MJ/l	=	7.2	kWh/l
	=	118.3	MJ/gal	=	32.8	kWh/gal

GLOSSARY

Air Changes (AC or AC/HR). A way to express ventilation rates, which are the number of times that the air volume of a given space will be replaced in a one-hour period. (AC/HR = CFM/square meter x 60/ceiling height).

Ambient temperature. The temperature of the surrounding air.

Automatic. Self-acting; operating by its own mechanism when activated by some impersonal influence -- such as, for example, a change in current strength, pressure, temperature, or mechanical configuration.

Ballast. A device used in starting circuit for fluorescent and high intensity discharge lamps.

Base load. Load on heating system which occurs regardless of outside temperatures, due to domestic hot water, laundry, kitchen equipment, et cetera.

Boiler capacity. The rate of heat output in Btu/hr. measured at the boiler outlet under rated conditions.

British thermal unit (Btu). A heat unit equal to the amount of heat required to raise one pound of water one degree Fahrenheit. (Btuh = Btu's per hour.)

Building envelope. All external surfaces that are subject to climatic impact -- for example, walls, windows, roofs, and floors.

Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating plant, under designated operating conditions.

Combustion Efficiency. A measure of the proportion of a heating fuel that is converted to useful heat energy. A boiler or furnace combustion efficiency of 80% means that 80% of each unit of heating fuel is converted to useful heat during the combustion process. The remaining 20% is lost in the form of hot exhaust gas from the combustion process and unburned fuel.

Condensate. Water caused by changing the state of water vapour that is steam or moisture in air from a gas to a liquid; usually caused by cooling.

Condenser. A heat exchanger that removes heat from a vapour, changing it to its liquid state. (In refrigeration systems, it is the component that rejects heat.)

Conduction. A method by which heat is transferred through a material or between different materials, as a result of direct contact.

Control Point. The value of the controlled variable which the controller actually maintains.

Convection. Heat transfer between two objects by means of an intermediate medium, such as air.

Cooling load. Rate of heat removal necessary for maintaining a space at the desired temperature, usually offset by supplying air at a temperature below that which is desired. Heat is removed from the space as the supply air is warmed up to the space temperature.

Demand (elec.). Peak rate of electric power consumption, during a monthly billing period, measured in kilowatts. It is usually averaged over a specific time period, such as 30 minutes.

Economizer cycle. A method of operating a ventilation system to reduce refrigeration load. Whenever the outdoor air conditions are more favourable (having lower heat content) than return air conditions, outdoor air quantity is increased.

Efficiency, overall system. The ratio of the useful energy (at the point of use) to the thermal energy input for a designated time period, expressed in a percentage.

Energy. The capacity for doing work; taking a number of forms that may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, and chemical; in customary units, measured in kilowatt-hours (kWh) or British thermal units (Btu).

Energy Index (EI). A reference that expresses the total energy (fossil fuel and electricity) used by a building in a given period (month, year) in terms of kWh/gross conditioned square meter.

Evaporator. A heat exchanger that adds heat to a liquid, changing it to a gaseous state. (In a refrigerator system, it is the component that absorbs heat.)

Exfiltration. Opposite of infiltration (see **Infiltration**).

Gross floor area. The sum of the areas of the floors of the building -- including basements, mezzanines, and intermediate floored tiers and penthouses of head-room height. Gross floor area is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings. Covered walkways, open roofed-over areas, porches, and similar spaces are excluded. The gross floor area does not include such features as pipe trenches, exterior terraces, steps, chimneys, roof overhangings, etc.

Gross wall area. The vertical projection of the exterior wall area bounding interior space that is conditioned by an energy-using system; includes opaque wall, window, and door areas.

Heat Gain. The amount of heat gained by a space, and coming from all sources, including persons, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed from a space in order to maintain indoor comfort conditions.

Heat Loss. The sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. Heat loss represents the amount of heat that must be provided to a space in order to maintain indoor comfort conditions.

Heating and cooling degree days. The concept of heating degree days was derived in an attempt to correlate the heating fuel consumed by buildings with the outside temperature. The number of heating degree days recorded for a particular day is the difference between 18°C (65°F) and the average outdoor temperature for that day -- if the outdoor temperature is less than 18°C (65°F). No attention is given to those days for which the average temperature is above 18°C (65°F).

For example: a day when the average temperature is 13°C (55°F) would result in 18°C-13°C = 5°C degree days (65-55 = 10°F degree days). A 29°C (75°F) day would not have any heating degree days, because the temperature was not below 18°C (65°F).

Heat pump. A refrigeration machine possessing the capability of reversing the flow, so that its output can be either heating or cooling. When used for heating, it extracts heat from a low temperature source and raises it to the point at which it can be used.

Humidity (relative humidity) A measurement indicating the moisture content of air. It is the ratio of the existing vapour pressure of the water in the air, to the vapour pressure of water in the air when it is saturated, at the same dry bulb temperature.

Infiltration. The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Insolation. Solar radiation that arrives at the earth's surface.

Kilovolt-Amps (KVA). Product of Volts x Amps x 1,000 for single phase power. For three phase power, this would also be multiplied by a factor of 1.73.

Kilowatt (KW). Standard unit for measuring the rate of electrical energy use; thousands of watts.

Kilowatt-Hour (kWh). Standard unit for electric energy consumption; the product of kilowatts x hours.

Life Cycle Cost. The cost of the equipment or entire facility over its entire life -- includes operating and maintenance costs.

Load profile. Time distribution of building's heating, cooling and electric load.

Lumen. Unit of luminous flux. A measure of lighting level.

Make-up. Water supplied to a system to relace that lost by blowdown, leakage, evaporation, etc.

Outside air. Air taken from the outdoors, and therefore not previously circulated through the system.

Packaged terminal air-conditioner. A factory-selected combination of heating and cooling components, assemblies, or sections intended to serve a room or zone.

Power. The time rate of doing work, as applied to machines. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (Btu/h).

Process energy. Energy consumed in non-HVAC processes, such as in a laundry or a kitchen, or in the production of domestic hot water.

Power factor. Relationship between KVA and KW. When the power factor is unity, KVA equals KW$\left(\text{P.F.} = \frac{\text{KW}}{\text{KVA}}\right)$

Rate schedule. The list of charges that the utility applies to its customers for the provision of energy.

Recovered energy. Energy, utilized from an energy utilization system, that would otherwise be wasted.

Reheat. The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space, by either mechanical refrigeration or the introduction of outdoor air, to provide cooling.

R-value. The resistance to heat flow. R = I/U (see U-factor).

RSI Value. The metric equivalent of R-value.

$$\text{RSI} = 0.176 \times \text{R}$$
$$\text{R} = 5.68 \times \text{RSI}$$

Reset. Adjustment, automatic or manual, of the set point of a control instrument to a higher or lower value, for the purpose of conserving energy.

Seasonal efficiency. A measure of furnace or boiler efficiency, including standby losses. Seasonal efficiency is always equal to or less than. Seasonal efficiencies for gas or oil-fired heating equipment range typically from 65 to 70%.

Electric boilers do not have combustion losses, but do have standby losses. The seasonal efficiency of electric boilers ranges typically from 90-95%.

Set point. The value on the controller scale at which its indicator is set.

Tons of refrigeration. Terminology for expressing cooling capacity (1 ton = 12,000 Btu/h).

'U' Value. A coefficient expressing the thermal conductance of a composite structure in Btu per (square foot) (hour) (degree F temperature difference).

Vapour barrier. A moisture impervious layer designed to prevent moisture migration. Also referred to as "air vapour barrier" since overall effect is to prevent air movement as well.

FURTHER INFORMATION

Ontario Housing Corporation Guidelines and Specifications

Ontario Housing Corporation

A series of detailed guideline and specification sheets describing energy conservation measures in multi-unit buildings. Subjects included in the series are lighting, garage ramp heater controls, insulation, weatherstripping, mnechanical ventilation and exhaust, water saving devices and the control of block heater power receptacles.

Energy Conservation Building Operations Demonstration for Gas-Heated High Rise Multiple Unit Residential Buildings

Engineering Interface Limited, 1982

Report on a series of case study demonstrations of energy management in high rise apartment buildings.

Energy Efficiency in Multi-Unit Residential Buildings: A Handbook for Owners and Operators

Canada Mortgage and Housing Corporation, 1982

Detailed handbook hat focuses on the energy efficient operation of mechanical systems for space heating, ventilation, water heating and air conditioning. Maintenance procedures and programs are explained thoroughly.

Energy Cost Reduction for Apartment Owners and Managers

Institute of Real Estate Management of the National Association of Realtors, U.S.A., 1977

Concise handbook outlining low cost/no cost energy conservation measures for space heating and cooling, water heating and lighting systems.

Handbook of Building Maintenance Management

Mel A. Shear
Reston Publishing Co. Inc., Reston, Virginia 22090, 1983

Comprehensive handbook describing building maintenance management techniques and procedures.

Energy Fact Sheets and Pamphlets

Ministry of Municipal Affairs and Housing, Housing Renovation and Energy Conservation Unit.

The Ministry of Municipal Affairs and Housing has produced a series of pamphlets and sheets on energy conservation. These pamphlets outline measures homeowners should consider when planning work or alterations around the house. They include:

First Seal Your House

A look at the importance and applications of reducing air leakage into and out of the home.

Make the Most of Your Heating System

A guide to important decisions affecting the homeowner's heating system. Improvements which can be made are outlined as well as guidelines for the purchase of new systems.

A Window Review

This pamphlet analyzes different approaches to window treatments, ranging from caulking and weatherstripping to adding more glass and movable insulation.

Home Energy Fact Sheets

Fact sheets have been published on a wide variety of subjects. These technical sources outline specific details of various conserving strategies. They include:

- Fresh Air and Humidity in a Tighter House
- Energy Checklist for Renovators
- Caulking and Weatherstripping
- Air-Vapour Barriers
- Improving Fireplace Efficiency
- Re-Insulating Basements
- Exterior Insulation
- Insulating Cathedral Ceilings and Flat Roofs

GOVERNMENT PROGRAMS

COSP Canada Oil Substitution Program

The Federal government is encouraging the use of gas, electricity and nonrenewable (sun, wood, etc.) energy instead of oil. COSP provides a taxable grant of up to $5,500.00 for centrally heated buildings that convert from oil.

Phone or write:

The Federal Conservation and Renewable Energy Council
2242 Lakeshore Blvd. West
Toronto, Ontario
M8V 1A5

1-800-268-2207 (toll free)
252-5866 (in Toronto)

CHIP Canadian Home Insulation Program

CHIP is a Federal program which provides a taxable grant of up to $285.00 per rental apartment unit. Buildings built before 1971 qualify for CHIP.

Phone your local CMHC office for application details. (In Toronto, call 789-0581.)

REAP Residential Energy Advisory Program

Loans are offered at Ontario Hydro's borrowing rate (currently about 5% below market). These can be used to upgrade energy efficiency. The program is offered by Ontario Hydro in part of its rural service area. Many local utilities are expected and authorized to introduce a similar program -- many already offer energy conservation advice. Call yours and ask.

BRIC Building Rehabilitation and Improvement Campaign

Provides financial assistance for architectural conservation to qualifying individual projects as well as heritage conservation districts. Check with the Ministry of Citizenship and Culture for details, 416-965-4021.

Housing Renovation and Energy Conservation Unit

For information about programs and projects in Ontario, call the Ministry of Municipal Affairs and Housing, HREC Unit: 416-965-4073.

Ontario
Renews

Renovation and Energy Conservation Unit
Ministry of Municipal Affairs and Housing
Queen's Park, Toronto M5S 1P8